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Indigenous knowledge to deter elephants damaging crop lands

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Abstract

Elephant and man conflict is becoming more and more common problem in Sri Lanka. As there is no solution, poor farmers face severe crops losses due to elephant attacks. Electric fences were also not effective due to rise in electricity cost and elephants get used to these methods and there are no effective methods so far. According to several ancient literature man elephant conflict was controlled by traditional and indigenous methods. Therefore, extensive literature surveys on research articles, ancient authentic texts, ancient books and news articles were conducted. Furthermore, focus group discussions with farmers were carried to extract information on the most successful methods to deter elephants from crops lands. Several successful methods were extracted and presented here in this paper to disseminate this valuable indigenous knowledge into the present generation. Methods identified were Beehive fences in the border of the farmland and when elephant touches the wires the disturbed swarm of bees attaches the elephant get into the crop's fields. Buffers of cultivation of Chili, which is an irritant, causing elephants to cough, sneeze and eventually turn away from the crop field. Vegetable buffer zones with unpalatable crops such as sisal (Agave sisalana), chili (Capsicum frutescens) tea (Camellia sinensis), ginger (Zingiber officinale), mustard (Brassica nigra) or oilseed (Brassica napus) is another method. These unpalatable crops may not necessarily deter the elephants, but these crops will not be raided and therefore the farmers' livelihood is ensured. When elephants crush the mustard plants, they feel the strong smell which the elephants do not like, and they turn back and go away. In addition, these crops will provide additional income to the farmers. Acoustic deterrents were used widely which are noises used to deter elephants, either by the shock value of an unexpected loud noise, or by specific noises that are known to scare elephants. Acoustic deterrents are disturbance shooting, elephant communication and Tigers on tape are few of them. Chemical deterrents such as chilli powers and chilli pasted robes are also used effectively. Physical barriers such as trenches, bamboo spike, sharp stones are also used to deter elephants. As the conclusion the above mentioned traditional and indigenous methods could be practiced with less cost and it will also be possible to gain additional income other than the main crop.

Key Words: *Elephant, deterrents, vegetable barriers, chemical deterrents, crop lands*

1. Introduction

Protection methods share a similar purpose that they are designed to reduce crop damage by deterring elephants entering cropping areas. However, there are many approaches, some experimental and some tested, from elephant rangeland across Africa and Asia. The fact that elephants can get used to any single deterrent has implications upon the selection and implementation of methods. It is recommended that a combination of techniques be employed in order to minimize the risk of elephants becoming used to any single method. New methods described in this paper are not meant to replace ones already in use in communities. Some methods will be based upon traditional methods already used for centuries. There is a variance in the level of technology, which is used, as well as the basis upon which the methods work, e.g. acoustic, olfactory or tactile. Protective measures are aimed at deterring elephants from coming to the fields of farmers. The techniques are based upon influencing elephant's behavior or ecology. Some techniques can be set up with locally available material. Traditional or Indigenous techniques imply techniques which have been used throughout history by local communities, and of which knowledge is passed on from generation to generation (Gunasekara and De Silva, 2022). They are most often based upon scaring elephants away from fields, in the hope that the elephants will return to more natural habitat. They generally utilize low-tech materials that are widely available. Most traditional methods are of limited use as a deterrent, usually only temporarily easing the problem, or shifting it to a neighboring area. Usually, a community will rely upon just a few methods, and these will be used repeatedly with little variation.

1.1 Human-Elephant Farming Conflict

Human-elephant farming conflict is prevalent throughout Africa and Asia. When elephants eat farmers' crops while foraging to meet their large caloric needs farmers are unable to maintain their livelihood. Elephants are large herbivores, on average elephants consume 250-300 pounds of foliage per day (International Elephant Foundation, 2018). They are mixed feeders that both browse and graze. Elephants rely on fruit as well as grass and shrubs for their diet and nutrition (McNaughton *et al*. 1988). Elephant crop raiding is an especially serious issue for farmers living adjacent to protected areas. These farmers consider elephants to be one of the most serious causes of crop damage (Hoare 2015; Megaze et al. 2017). One study assessed the frequency and severity of crop-raiding damage caused by a wide variety of species. Researchers found that although signs of elephants were minimal, the majority of participants reported that elephants damaged their crops (84%) and soil (71%) elephants drinking their water (Harich *et al*. 2013). Further elephant crop-raiding is problematic for farmers due to its severity rather than its frequency (Hoffmeier-Karimi & Schulte 2015). The severity of elephant crop damage creates epicenters of human-elephant farming conflict that most detrimentally impacts subsistence farmers, because farmer's production matches their consumption with little or no surplus (Sitati *et al.* 2005). Poorly guarded farms are most susceptible to elephant crop-raiding (Sitati et al. 2005). In just one night, a family of elephants can destroy a farmer's entire field (Wittemyer 2001). Elephant crop-raiding behavior is most severe during peak ripening, just before crops are ready to harvest (Chiyo et al. 2005; Sitienei et al. 2014; Thouless 1994). This imposes a serious threat to

subsistence farmers' economic stability, earning potential and livelihood (Hedges and Gunaryadi, 2010; Mackenzie & Ahabyona 2012; Sitati *et al.* 2005; Sitienei *et al.* 2014). These financial losses to the farming communities may render families unable to pay necessary expenses, meet their families' basic needs and childhood education (Harich *et al*. 2013). In Africa, unfortunately, children under the age of eighteen are often needed to protect these fields and its impacts children's access to education (Mackenzie & Ahabyona 2012; Thouless 1994). In Tanzania, sixty percent of students reported not attending schools to guard crops which degrades children's academic performance and scored worse on national exams than students living in communities not impacted by wildlife (Mackenzie & Ahabyona, 2012). Over time, poor academic performance may limit children's employment opportunities or their ability to pursue higher education (Smith and Kasiki 1999). Small-scale farmers are often unable to address the underlying causes of human elephant farming conflict. They focus their energy on minimizing crop damage by deterring elephants. Therefore, in this study examine different strategies that farmers employ to reduce elephant crop-raiding damages based on extensive literature survey and authentic texts of indigenous knowledge.

2. Methodology

Several research papers and internet-based research and comprehensive articles were used to get indigenous methods used to deter elephants for centuries used by local communities in Asia and Africa. Further information was collected by focus group interviews conducted in the areas where elephant interference with crop fields, newspapers and news broadcasted. There were several methods explained under the findings used by local communities centuries ago.

3. Results and Discussion

3.1 Beehive fences

Elephants are afraid of bees, especially the aggressive African honeybees. These bees' stings can be extremely painful even for the thick-skinned elephants, especially inside their trunk or around their eyes (King, *et al*., 2017). In 2002, researchers found that African elephants stay away from acacia trees with beehives. Later studies showed that not only do the elephants run away from the sound of buzzing bees, they also emit low-frequency alarm calls to alert family members about the possible threat (Figure 1). The fence consists of beehives hung every 10 m, linked by wires. When an elephant touches the fence, the beehives swing, unleashing a swarm of angry bees (King, *et al.*, 2011). They are particularly good at stopping raids by overwhelmingly large groups of elephants. Honey and other bee products earn the farmers an additional income (King et al, 2009; King et al, 2017a, Kings et al, 2017b).

3.2 Buffers of Chilli Cultivation

Elephants don't like chilli. Capsaicin, the chemical in chilli that makes them hot, is an irritant, causing elephants to cough, sneeze and eventually turn away (Figure 2). Some farmers in Africa protect their crops from elephants by planting buffers of chilli

(*Capsicum frutescens)* plants around them. The chilli also earns them extra money. The Elephant Pepper Development Trust in Cape Town, South Africa, teaches farmers to make rope fences smeared with waste engine oil and red chilli, and mounted with cowbells, to deter elephants (Chang'a, *et al*. 2016). Capsicum powder has been tested on refuse dumps and applied to fence posts to stop elephant damage. Elephants have been repelled from fields by burning a mixture of capsicum powder and elephant dung. Additionally, a mixture of grease and capsicum, applied to string fences, reduced the regularity of incursions by elephants into fields.

Figure 1. Beehives in the boundary of the crop lands.

3.3 Vegetative barriers

Vegetative barriers are put up by planting certain plant species which have features to deter elephants. Besides providing a barrier to approaching elephants, they could also serve to demarcate farms.

Barrier of unpalatable crops

One can reduce the attractiveness of cultivated areas by planting unpalatable crops in vulnerable areas, e.g. on farms at the edges of protected areas. Crops may include sisal, chili, tea, ginger or oilseed. These unpalatable crops may not necessarily deter the elephants. However, these crops will not be raided and therefore the farmers' livelihood is ensured (Hedges and Gunaryadi, 2010).

Buffers of Mustard Cultivation

Mustard cultivated near to the forest to avoid damage from the wild elephants. When elephants crush the mustard plants, they feel the strong smell which the elephants do not like, and they turn back and go away. Having buffer zones of mustard cultivation where elephants enter the cultivated land will help to stop entering the

cultivated land. In addition, farmers can gain income from mustard cultivation (Karmakar, 2023; Mehta *et al*, 2012).

Figure 2. Chilli (Kochchi)(*Capsicum frutescens*) used to repel elephants

Figure 3. Agave plants in the boundary deter elephants.

Buffer zones

The purpose of a buffer is to create a zone of reduced attractiveness between the conservation area and the surrounding crops. This involves clearing secondary forest on the boundary and creating some physical distance between the boundary and cultivation. An optimal buffer zone should contain unpalatable crops (such as sisal) grown adjacent to sub-optimal elephant habitat (Perera, 2009).

Agave and Cactus

Thorny plants of agave and cactus can be planted on the boundary of the farm (Figure .3). These plants grow tall and are thorny, so the elephants find it difficult to enter through them (Mehta *et al*, 2012).

Lemon

Elephants do not like the smell of lemon. Therefore, lemon trees can be planted on the boundary of the farm. When the trees have become big, thick, and thorny, elephants avoid the area with lemon trees. Lemon fruits, or pickle made can be sold and generate additional income (Perera, 2009).

Sunflowers

Elephants do not like sunflowers and do not eat sunflowers. They only picked it and threw it away. Farmers in the sample reported that sunflowers provide numerous benefits. At the top of the list was their edibility; for example, farmers can eat sunflower seeds. The seed of sunflower makes good oil. Sunflower oil can be used for cooking. Sunflower seeds and cooking oil can be consumed by the household or sold as an income source. Sunflower seeds can also be used as livestock feed. After being pressed for oil, livestock can eat the remaining seed husks. Some farmers grew sunflowers because they benefit their bee colonies. A beehive fence farmer remarked, "Elephants don't like sunflowers, but it's attractive to bees. Bees use sunflowers as a food source. According to a farmer, Sunflower helps also in the pollen grains. Sometimes the bees use it for preparing the honey. In addition, when farmers plant sunflowers near beehives, the hives become more attractive to bees, which may increase beehive occupation rates and honey production. In addition to sunflower's numerous material benefits, farmers also planted them because they are aesthetically pleasing. While sunflower cultivation can be beneficial to humans and other species, growing them can be difficult for farmers (Weinmann, 2018).

Moringa

Fifty percent of farmers interviewed reported that the Moringa is not attractive to elephants. "Once they have flowers, they release a scent, which is not attractive to elephants. The agriculture expert attested that elephants dislike moringa. Most farmers agreed that moringa cultivation offers numerous benefits. The most reported benefit was that moringa can be eaten as a vegetable. Can use the leaves as vegetable and the flower is used as a spice. Moringa can be eaten fresh or dried and stored for later; in both forms it is highly nutritious. A farmer noted, "Seed pods are good vegetable . . . The leaves, when dried and taken with porridge, are good for health. The seeds can also be pressed for oil. Another important benefit of moringa is its curative properties.

The seeds help us a lot. It is used as medicine for those with hypertension. Farmers use the flowers, seeds, and leaves as medicine. In addition, moringa's biological properties make it well suited for cultivation. It is not affected mainly by the weather because it's a tuber. It stores water. It waits and grows up when rain comes again. Therefore, it can withstand unreliable rainfall and extended drought when crops like

maize are unlikely to survive. Moreover, moringa creates oxygen and serves as a carbon sink within the ecosystem. The agriculture expert highlighted the ecological importance of moringa is drought tolerance. Although they have no rain, the oil crops do very well here, medicinal crops that's moringa, baobab, sunflower.

Moringa is also a legume, so it's also good for agroforestry if someone is growing other plants. It's a nitrogen-fixer. Moringa can play an important role in the agro-ecological system. Importantly participating farmers were keen to learn more about moringa and begin cultivation on their farms. The sunlight is too strong. Greater knowledge could make moringa a more viable option for farmers. They can sell flowers, seeds and pods for money. There are several local markets for moringa. While elephants are not damaging Moringa farmers can earn money from Moring cultivation (Weinmann, 2018).

Medicinal plants

In a study seven medicinal and aromatic plants (MAPs) containing higher amounts of specific plant and secondary compounds were explored to reduce the damage by elephants on rice and maize. Research studies showed that chamomile, coriander, mint, basil, turmeric, lemon grass and citronella were less attractive and were not consumed by elephants compared to rice (Gross *et al*, 2017).

3.4 Acoustic deterrents

Acoustic deterrents are noises which are used to deter elephants, either by the shock value of an unexpected loud noise, or by specific noises that are known to scare elephants (Zeppelzauer, 2015).

Disturbance shooting

Disturbance shooting is the firing of gunshots over the heads of crop-raiding elephants. Used across the continent, disturbance shooting has been a long-standing deterrent. However, it is at best considered a temporary respite from elephants, as there is a large body of anecdotal evidence to suggest that elephants habituate to gunshots if exposed to them for a prolonged period of time. This method relies upon centralized units responding to the problem and is therefore constrained by transport and logistical problems (Perera, 2009).

Elephant communication

Several studies of elephant communication have demonstrated possibilities for manipulating elephants' behavior with playbacks of vocalizations. Some research has been done into using elephant communication as a deterrent; researchers in Namibia recorded elephant warning calls and played these back to elephants in order to scare them away.

In another study, bull elephants were attracted by playbacks of recorded 'post-copulatory rumbles. There are a number of other calls that could be used to attract or repel elephants that are less well understood, but perhaps could be used in the future (Poshitha *et al*, 2015).

Alarm systems

Alarm systems are acoustic devices that are usually established at the boundary of the farms and set off by a tripwire. The loud noise from the alarm when the elephant touches the trip wire is primarily meant to alert farmers to the presence of elephants, but it also has some deterrent effect (Perera, 2009).

Bells

In Zimbabwe cowbells were strung along a simple string fence at the edge of vulnerable fields. As the elephants attempted to enter the fields, they started the bells ringing and this alerted the farmers to the elephant's presence (Perera, 2009). .

Electric sirens

Using sirens that were triggered when elephants contacted the trip wire is also a method. In Sri Lanka researchers have found similar success with such methods. The limitations are that in high rainfall conditions it is difficult to maintain electrical systems, and they are also vulnerable to theft (Perera, 2009; Poshitha *et al*, 2015).

Tigers on tape

Tigers and elephants often live side by side. While tigers don't usually hunt elephants due to their size, they have been known to kill elephant calves. Therefore, elephants are wary of tigers. Recorded the aggressive growls of a captive tiger and leopard and played them to elephants frequenting villages around two protected areas in southern India (Thuppil and Coss, 2016). Whenever the elephants ventured close to crop fields, they tripped an infrared beam, triggering playbacks of the growls. On hearing the agitated tiger growls, the elephants silently retreated (Wijayagunawardane *et al*, 2016).

Noise

The most common way that farmers attempt to chase elephants out of fields is by making loud noises. Farmers use a range of noisemakers, such as beating drums, tins and trees, 'cracking' whips in addition to yelling and whistling to chase elephants (Wijayagunawardane *et al*., 2016).

Missiles

Farmers throw rocks, burning sticks and, occasionally, spears at crop-raiding elephants. This usually involves getting close to the animals, and therefore the danger level is high.

Bamboo Blasters

Farmers create a hole in a piece of bamboo stick measuring about 45cm long. A powdered chemical substance called calcium carbide is then poured into the hole. About a spoonful of water is sprinkled on the chemical substance and the hole is

covered for a few minutes. A white stream of vapor comes out of the hole when the covering is removed, and when lighted it makes a great noise (Perera, 2009).

Fire

Fires are lit on the boundaries of fields or are carried as burning sticks by the farmers. Approaching elephants will get deterred by the smoke, or anxiety of the flames. This method becomes ineffective when it rains since the fires are usually put off (Perera, 2009).

3.4 Physical barrier systems

Barriers work on the principle of physically excluding elephants from the crop fields. The method involves putting up physical barriers in the pathways of elephants toward them off from crop fields. A wide range of potential methods exists.

Trenches

In Asia, digging trenches along a park boundary or around water points has been pursued with varying degrees of success. The concept is to dig a trench that is wide and deep enough so that an elephant cannot step over it (elephants are not able to jump) (Figure 4). In some places, trenches are filled with pointed sticks to further deter elephants from crossing (Perera, 2009). The major drawback with trenches is that, if dug on a slope, they encourage soil erosion. Elephants have also been known to fill them in by kicking soil from the edges into the trench, thereby filling it and enabling them to cross. Trenches require a large initial investment of labor and intensive maintenance (Graham *et al*., 2009b; Massey *et al*., 2014).

Figure 4. Trenches to deter elephants crossing.

Covered trenches

Experiments with shallow trenches overlain with branches and leaves have been successful in India. When an elephant treads upon the leaves it feels the substrate give and fears it will plunge into a pit, so it withdraws. The trench need only be 30 cm deep, but it must be wide enough to prevent an adult bull from stepping right over it. The covering must be well maintained, because once an animal realizes that this is a hoax, this tactic will be ineffective. This method requires a great deal of labor and in high rainfall areas soil erosion may be a problem (Perera, 2009).

Bamboo spikes

Short lengths of bamboo are sharpened and dug into the ground so that the spike protrudes vertically from the soil. Spikes must be positioned close together and in a wide band so that the elephant can neither step between the spikes, nor step over the entire barrier. Elephants will not tread on the spikes, as they require large surface area to distribute their weight. In areas where bamboo is readily available this method would be cost-effective, but the limitations would be the labor and time involved in the construction (Perera, 2009).

Sharp stones

A barrier of sharp stones is laid out in a broad band and the elephants will avoid crossing them (as above). The method is time-consuming and labor intensive, but ultimately cheap and low maintenance. It would require access to a large number of suitable stones (Perera, 2009).

Brick walls around water structures

A barrier of bricks is constructed around water structures to prevent elephants from crossing them. Walls need to be at least two large rocks in width, and 1.8m high and a sufficient distance from water tanks and pumps to prevent elephants reaching the installations from outside the wall.

Barriers with natural material

One of the most common barrier materials is thorn branches. Logs and sticks are also piled up around the edges of fields (Figure 5). In some areas farmers simply run bark ropes from tree to tree and hang pieces of white cloth from the line. Brightly colored cloths and plastic are hung from a simple fence at the edge of the fields. Such visual deterrents may have an initial 'scaring' value, but it is unlikely this method would provide any reliable protection. None of these barriers can stop a determined elephant but any boundary to cultivated area creates a psychological barrier that can have some impact. The most important aspect is the availability of the materials to build the barriers. The limitation of barriers is that they are generally expensive to construct, require a lot of labor and require high levels of maintenance. Much anecdotal evidence suggests that elephants will overcome even the most sophisticated barriers over time. In addition, permanent barriers may not be popular with farmers as they are seen as a restriction on agricultural expansion (Perera, 2009).

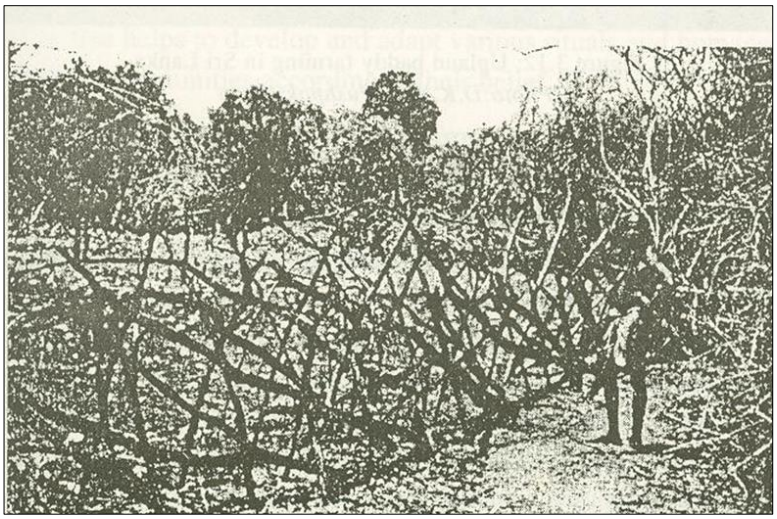

Figure 5. Barriers with natural materials (*Dandu weta*)

3.5 Chemical deterrents

Chemical compound(s) with potential deterrent capabilities may prove an effective way to deter elephants, either as an unpleasant or painful smell, or as a targeted compound such as a hormone, which creates fear.

Capsicum deterrent

Repellents based on resin from Capsicum spp. (Chili peppers) have been used to alter animal behavior for a variety of species, including bears, ungulates, dogs, and humans. The resin contains capsaicin, a chemical found in fruits of Capsicum spp., which is the agent that makes them taste hot. The irritating quality of this stimulation produces a burning sensation that mammals find extremely unpleasant (Chang'a, 2016).

Chili bricks

Chili bricks are a low-tech technique that evolved from pepper spray. Working on the same principles that elephants are repelled by Capsicum, the chili bricks only utilize simple, locally available materials. Dry chili is mixed with elephant or cattle dung and compressed into bricks. The bricks are then sun-dried and burnt at the edge of the fields. The bricks burn slowly and produce a strong-smelling cloud of chili smoke (Chang'a, 2016).

Pepper Spray

To extract the capsaicin, peppers are soaked in solvents. The amount of 'heat' in a pepper is measured in Scovil Units. A very hot pepper measures approximately 30,000 SU. The capsaicin is mixed with soybean oil and inserted into an aerosol can with a modified spray nozzle (similar to hairspray). The mixture is then pressurized

and when the trigger is depressed, an atomized spray cloud is produced. Atomizing the capsaicin into a gas cloud makes it an extremely effective irritant. The effects of pepper spray on elephants are far more severe, including temporary blindness which last from 15-30 minutes and a burning sensation of the skin which last from 45 to 60 minutes Chang'a, 2016).

4. Conclusion

Elephants damaging the crop land, and the livelihood of poor and rural population is the great problem in Sri Lanka. Even though there were electric fences to protect the cropland and villages elephants get used to this system and damage the electric fences too. Therefore, this study intended to identify the traditional methods used in other countries so that farming communities could adopt these methods to deter elephants damaging crop lands. Based on the literature and research findings, several traditional low-cost methods are identified and summarized in this paper to aware he local communities. Instead of electric fences the Beehive fences will be more useful, and farmers can gain additional income too from the honey and other products. Buffers of chilli cultivation too reported to deter elephants. There are also several vegetative barriers using unpalatable crops such as tea, mustard, ginger, oilseed, agave and cacti, sunflower, moringa, and lemon are a few of them successfully deter elephants from croplands. Research studies showed that medicinal plants such as chamomile, coriander, mint, basil, turmeric, lemon grass and citronella were less attractive. Furthermore, acoustic deterrents such as shooting, bells, noise, tiger growing, and fire are also found as methods to deter elephants. Physical barriers such as trenches, *dandu weta* and bamboo spikes were also used by local communities to deter elephants. Several chemical deterrents such as chilli and pepper sprays are also used to deter elephants damaging crop lands. Therefore, local communities facing elephants damaging croplands could use any of the low-cost methods to deter elephants. Since elephants get used to any method very quickly, local communities need to try several of the methods used in this paper.

5. References

Chang'a, A., de, N. S., Muya, J., Keyyu, J., and Mwakatobe, A., Malugu, L., et al. (2016). Scaling-up the use of chili fences for reducing human elephant conflict across landscapes in tanzania. *Trop. Conserv.* Sci. 9, 921–930. doi: 10.1177/194008291600900220

Gross, E. M., Drouet-Hoguet, N., Subedi, N., and Gross, J. (2017). The potential of medicinal and aromatic plants (MAPs) to reduce crop damages by Asian Elephants (Elephas maximus). *Crop Protect.* 100, 29–37. doi: 10.1016/j.cropro.2017.06.002

Graham, M. D., Douglas-Hamilton, I., Adams, W. M., and Lee, P. C. (2009a). The movement of African elephants in a human-dominated land-use mosaic. *Anim. Conserv.* 12, 445–455. doi: 10.1111/j.1469-1795.2009.00272.x

Gunasekara, H.K.L.K., and De Silva, C.S. (2022). *Indigenous Knowledge in Farming Systems in Sri Lanka.* Generis Publishing, pp 73-81.

Harich, Franziska K., Anna C. Treydte, Joachim Sauerborn and Erasmus H. Owusu. (2013). "People and Wildlife: Conflicts Arising around the Bia Conservation

Area in Ghana." *Journal for Nature Conservation 21*(5):342-349. doi: 10.1016/j.jnc.2013.05.003

Hedges, Simon and Donny Gunaryadi. 2010. "Reducing Human–Elephant Conflict: Do Chillies Help Deter Elephants from Entering Crop Fields?" *Oryx 44*(1):139-146

Hoffmeier-Karimi, Rebekah R. and Bruce A. Schulte. 2015. "Assessing Perceived and Documented Crop Damage in a Tanzanian Village Impacted by Human-Elephant Conflict (HEC)." *Pachyderm* (56):51-6

Hoare, Richard. 2015. "Lessons from 20 Years of Human-Elephant Conflict Mitigation in Africa." *Human Dimensions of Wildlife 20*(4):289-295

International Elephant Foundation. 2018. *"Elephant Facts."*. (https://elephantconservation.org/elephants/just-for-kids/

Karmaker, R. (2023) In Assam, blinking LEDs being used as jumbo deterrents. IST-Guwahati, *The Hindu* News Article.

King, Lucy E., Anna Lawrence, Iain Douglas-Hamilton and Fritz Vollrath. 2009. "Beehive Fence Deters Crop-Raiding Elephants." *African Journal of Ecology 47*(2):131-137.

King, L. E., Douglas-Hamilton, I., and Vollrath, F. (2011). Beehive fences as effective deterrents for crop-raiding elephants: field trials in northern Kenya. *Afr. J. Ecol. 49,* 431–439. doi: 10.1111/j.1365-2028.2011.01275.x

King, L. E., Lala, F., Nzumu, H., Mwambingu, E., and Douglas-Hamilton, I. (2017a). Beehive fences as a multidimensional conflict-mitigation tool for farmers coexisting with elephants. *Conserv. Biol. 31*, 743–752. doi: 10.1111/cobi.12898

King, L. E., Lala, F. Nzumu, H., Mwambingu, E. and Hamilton, I. D. (2017b). Beehive Fences as a Multidimensional Conflict-Mitigation Tool for Farmers Coexisting with Elephants." *Conservation Biology 31*(4):743-752

Mackenzie, C., and Ahabyona, P. (2012). Elephants in the Garden: Financial and Social Costs of Crop Raiding." *Ecological Economics 75*:72-82

Massey, A. L., King, A. A., and Foufopoulos, J. (2014). Fencing protected areas: a long-term assessment of the effects of reserve establishment and fencing on African mammalian diversity. *Biol. Conserv. 176*, 162–171. doi: 10.1016/j.biocon.2014.05.023

McNaughton, S. J., R. W. Ruess and S. W. Seagle. (1988). "Large Mammals and Process Dynamics in African Ecosystems." *Bioscience 38*(11):794-800.

Megaze, A., Balakrishnan, M and Belay, G. (2017). Human-Wildlife Conflict and Attitude of Local People Towards Conservation of Wildlife in Chebera Churchura National Park, Ethiopia." *African Zoology 52*(1):1-23.

Mehta, P., Jayant Kulkarni, J. and Hiremath, U. (2012). *How to Protect Your Crops from Elephants. A Handy Guide for Farmers and Forest Department. Wildlife Research and Conservation Society.* pp 1-14

Perera, B. (2009). The human-elephant conflict: A review of current status and mitigation methods. *Gajah 30*, 41–52. Available online at: http:// maraelephantproject.org/wp-content/uploads/2016/04/The-HumanElephant-Conflict-A-Review-of-Current-Status-and-Mitigation-Methods. Pdf

Poshitha, D., Suduwella, C., Sayakkara, A., Sandaruwan, D., Keppitiyagama, C., De Zoysa, K., et al. (2015). "Listening to the giants: using elephant infra-sound to solve the human-elephant conflict," in *Proceedings of the 6th ACM*

Workshop on Real World Wireless Sensor Networks (Seoul). doi: 10.1145/2820990.2821000

Sitati, N.W., Matthew J. W and Williams, N.L. (2005). Factors Affecting Susceptibility of Farms to Crop Raiding by African Elephants: Using a Predictive Model to Mitigate Conflict." *Journal of Applied Ecology 42*(6):1175-1182

Sitienei, A. J., Jiwen, G and Ngene, S.M. (2014). Assessing the Cost of Living with Elephants (Loxodonta Africana) in Areas Adjacent to Meru National Park, Kenya." *European Journal of Wildlife Research 60*:323-30

Smith, R. J. and Kasiki, S. (1999). *A Spatial Analysis of Human-Elephant Conflict in the Tsavo Ecosystem, Kenya.* Gland, Switzerland.

Thuppil, V., and Coss, R. G. (2016). Playback of field growls mitigates crop raiding by elephants Elephas maximus in southern India. *Oryx 50*, 329–335. doi: 10.1017/S0030605314000635

Thouless, C. R. (1994). "Conflict between Humans and Elephants on Private Land in Northern Kenya." *Oryx*, *28*(2), 119-127. doi:10.1017/S0030605300028428 166

Thouless, C. R., H. T. Dublin, J. J. Blanc, D. P. Skinner, T. E. Daniel, R. D. Taylor, F. Maisels, H. L. Frederick and P. Bouche. (2016). *African Elephant Status Report 2016: An Update from the African Elephant Database.* Gland, Switzerland: IUCN

Weinmann, S. (2018). *"Impacts of Elephant Crop-Raiding on Subsistence Farmers and Approaches to Reduce Human-Elephant Farming Conflict in Sagalla, Kenya".* Graduate Student Theses, Dissertations, & Professional Papers. 11194.

Wijayagunawardane, M. P. B., Short, R. V., Samarakone, T. S., Nishany, K. B. M., Harrington, H., Perera, B. V. P., et al. (2016). The use of audio playback to deter crop-raiding Asian elephants. Wildl. *Soc. Bull. 40,* 375–379. doi: 10.1002/wsb.652.

Zeppelzauer, M., Hensman, S., and Stoeger, A. S. (2015). Towards an automated acoustic detection system for free ranging elephants. *Bioacoustics 24*, 13–29. doi: 10.1080/09524622.2014.906321