Guide for Implementing Community-Based Electric Fences

FOR THE EFFECTIVE MITIGATION OF HUMAN-ELEPHANT CONFLICT

Prithiviraj Fernando

Centre for Conservation and Research, Sri Lanka

LED BY

WORLD BANK GROUP

SUPPORTED BY

gef

PARTNERSHIP WITH

CCR

Centre for Conservation and Research-Sri Lanka

1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000

Internet: www.worldbank.org

This publication was developed with funding provided by the Global Environment Facility (GEF) through the Global Wildlife Program (GWP).

About the Global Wildlife Program

The GWP is a World Bank–led global partnership that promotes wildlife conservation and Sustainable development by combating illicit trafficking in wildlife. This seven-year, US$131 million grant program, funded by the GEF, aims to promote investments across 19 countries in Africa and Asia. The GWP seeks to reduce the trafficking of and demand for illegal wildlife trade both through national-level projects of integrated landscape planning that invest in the protection of species and habitats and through a global project that brings key stakeholders together to exchange knowledge and increase coordination. GWP national project investments include interventions linked to wildlife-based tourism as an important mechanism for inclusive poverty reduction and wildlife conservation.

Rights and Permissions

Photographs courtesy of Centre for Conservation Research Sri Lanka, unless otherwise noted.

This guide book was authored by **Prithiviraj Fernando** of the *Centre for Conservation and Research*, Sri Lanka with contributions by **Sampath Ekanayake**, and **Jennifer Pastorini**. **Ahimsa Campos-Arceiz**, **Darshani De Silva**, **Iretomiwa Olanji**, **Garo Batmanian**, **Richard Hoare**, **Sumith Pilapitiya**, **Claudia Sobrevila**, **Alexandra Zimmermann**, **Hasita Bhammar** and **Manali Baruah** reviewed and provided feedback

Guide for Implementing Community-Based Electric Fences

FOR THE EFFECTIVE MITIGATION OF HUMAN-ELEPHANT CONFLICT

SUPPORTED BY

IMPLEMENTING PARTNERS

PROGRAM STEERING COMMITTEE PARTNERS

Contents

1. INTRODUCTION 11

1.1. Human-Elephant Conflict 11

1.2. Correlates of Elephant Behavior and Ecology HEC 11

1.3. Factors Contributing to HEC Escalation 12

1.4. Approaches to HEC Mitigation 12

2. ELECTRIC FENCES 14

2.1. Principles of Electric Fencing 14

2.2. Approaches to Electric Fencing 16

2.3. Fence Breaking by Elephants 16

3. COMMUNITY-BASED VILLAGE ELECTRIC FENCES 20

3.1. Village Selection for Community-Based Fences 20

3.2. Fence Location 21

3.3. Fence Management 24

3.4. Community Organization 24

3.5. Community Financial Contribution 25

3.6. Community Labor Contribution 26

3.7. Fence Monitoring 26

3.8. Implementation Agencies 26

3.9. Personnel Implementing Community-Based Fencing Programs 27

3.10. Selection of Fence Materials and Equipment 27

3.11. Required Materials 34

3.12. Cost of Fence Material 36

3.13. Assessing Fence Effectiveness 37

3.14. Guidelines, Activities, and Protocols 37

Annex 3A Questionnaire for surveying Village Residents (Before Fence) 54

Annex 3B Village Fence Monitoring 58

Annex 3C Questionnaire for Assessing Fence Effectiveness (After Fence) 60

4. COMMUNITY-BASED SEASONAL AGRICULTURE ELECTRIC FENCES 64

4.1. Seasonal Fences 64

4.2. Fence Breaking by Elephants 65

4.3. Selecting Agricultural Tracts for Community-Based Fences 65

4.4. Fence Location 65

4.5. Fence Management 67

4.6. Community Organization 68

4.7. Community Financial Contribution 68

4.8. Community Labor Contribution 69

4.9. Fence Monitoring 69

4.10. Implementation Agencies 70

4.11. Personnel Implementing Seasonal Agriculture Electric Fencing Programs 70

4.12. Selection of Fence Materials and Equipment 71

4.13. Required Materials 76

4.14. Cost of Fence Materials 78

4.15. Assessing Fence Effectiveness 78

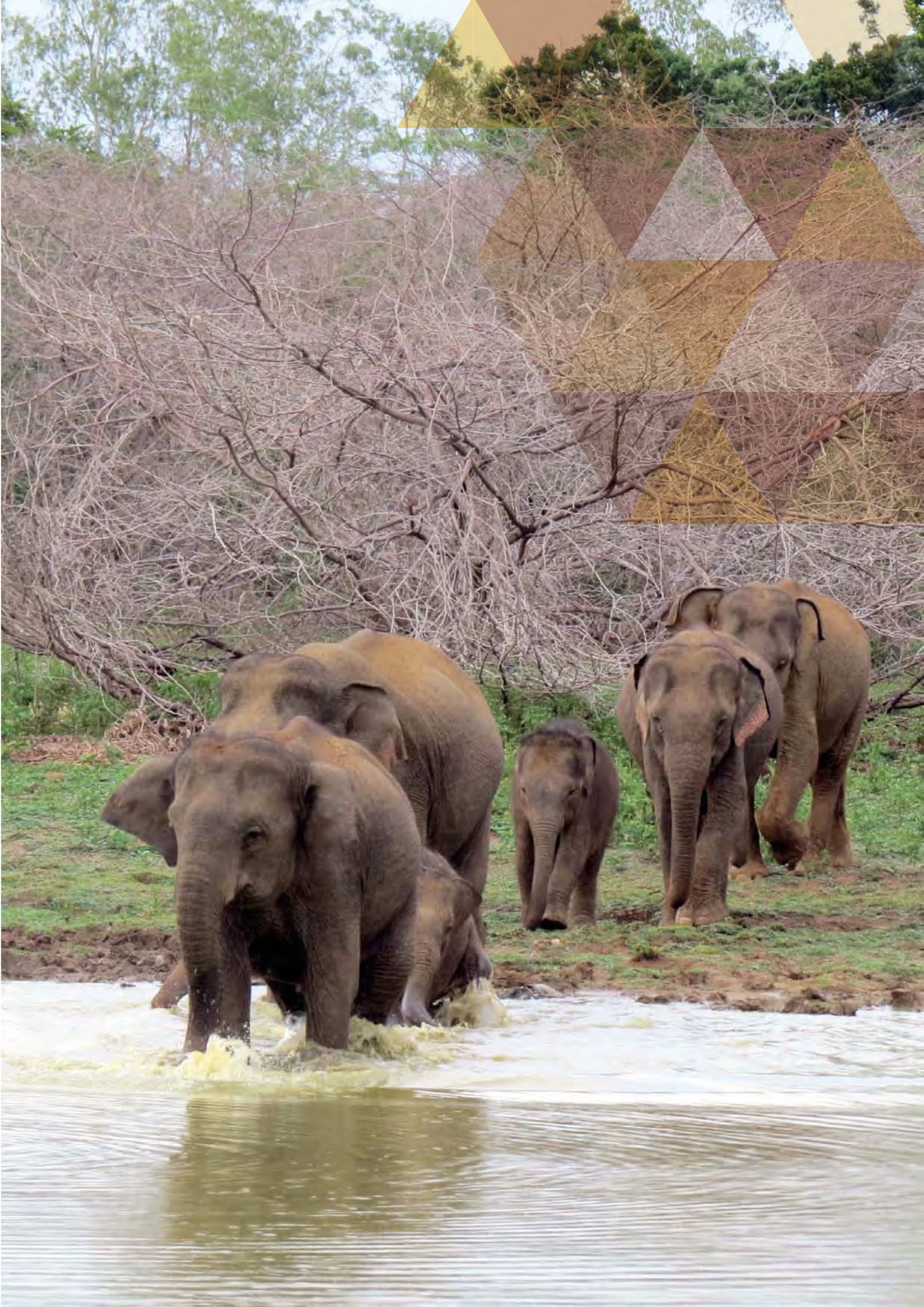
4.16. Guidelines, Activities, and Protocols 78

Annex 4A Questionnaire for surveying Farmers (before fence) 91

Annex 4B Agriculture Fence monitoring 95

Annex 4C Questionnaire for Assessing Fence Effectiveness (After Fence) 97

References 101



Introduction to the Guide

Human-elephant conflict is a major conservation, socio-economic and political issue over most of the African and Asian elephant range states. Conventional attempts at its mitigation by limiting elephants to protected areas have not been very effective in virtually all elephant range states. In most range countries, people and elephants exist in the same landscape outside designated protected areas.

Sri Lanka has the highest density of Asian elephants with a population of around 6000 elephants in the wild. It has 97 protected areas covering approximately 13 % of the country's land area, 70% of the wild elephants range outside the protected area network. This has resulted in Sri Lanka having the highest level of human-elephant conflict in the world. The country has been grappling with the increasing human-elephant conflict problem for the last 50 years. Some of the key interventions attempted in Sri Lanka are the capture translocation of problem elephants, large-scale elephant drives from areas earmarked for development, and confining elephants to Department of Wildlife Conservation Protected Areas through electric fencing established on the boundaries of the protected areas. Yet, approximately 250 elephants and 70 humans are killed annually due to this conflict.

Because of this critical situation in human-elephant conflict, the Government of Sri Lanka (GoSL) requested financial support from the WBG to address these issues along with support for improving the management and stewardship of the country's protected area system. The World Bank has been financing an International Development Association (IDA) loan "Ecosystems Conservation and Management" to the GoSL since 2016. One of the key interventions of the project is to "test innovative models for converting human-elephant conflict to a situation of human elephant coexistence in partnership with the affected local communities." This project is supporting the up-scaling of a successful pilot program on community based electric fencing implemented by the Centre for Conservation and Research (CCR) in Sri Lanka. This guide is a result of this pilot initiative. The IDA project implemented by the GoSL has already invested on community based permanent village electric fences and seasonal agricultural electric fences and will continue to do so. In April 2017, the Global Wildlife Program (GWP) on request from the National Parks Agency in Gabon organized a conference on "Reducing Human-Wildlife Conflict and Enhancing Co-Existence". The World Bank is currently leading a US $9.1 million project with the aim to reduce human-elephant conflict in Southern Gabon. Government representatives from 19 GWP countries, who participated in the GWP Gabon Conference expressed interest in learning more about tools and techniques such as the appropriate use of electric fences in mitigating human-elephant conflict and from the recently developed successful community-based human-elephant coexistence models in Sri Lanka. Thus, the GWP organized a study tour to Sri Lanka so that countries which are part of the GWP can benefit from a knowledge exchange on this topic. Seventeen delegates from 13 GWP countries in Asia and Africa participated in this study tour.

The participating countries included Botswana, Cameroon, Gabon, Ethiopia, India, Mali, Malawi, Mozambique, Republic of Congo, Thailand, Vietnam, Zambia, and Zimbabwe (see Annex II for participants). The delegates consisted of Directors and Deputy Directors of National Parks and Wildlife, Project Coordinators and Implementers.

The delegates expressed that the concepts and principles of community based electric fencing would be applicable in addressing the human elephant conflict in their respective countries. To disseminate the experience of community based electric fencing in Sri Lanka and create awareness among officials and affected communities in their own countries, the delegates requested GWP assistance in the preparation of guidebooks on community based electric fencing which could be used by respective countries in developing country specific criteria for electric fences to convert the human elephant conflict into human elephant coexistence.

The purpose of this technical guide is to assist countries participating in the GWP program in addressing human elephant conflict and exploring ways for coexistence between humans and elephants. The guide comprises of four chapters. This guide can prove to be very useful to implement future sites in Sri Lanka, as well. Chapter 1 provides background on human elephant conflict, contributing factors to escalation of conflict, and approaches to HEC mitigation. Chapter 2 provides information on the principles, concepts and rationale for locating electric fences properly to mitigate human elephant conflict. Chapters 3 and 4 present the general guidelines for the construction of *permanent village electric fences and seasonal agricultural electric fences* respectively. Chapters 3 and 4 can be read independent from each other depending on whether the interest is in protecting villages or agriculture. However, usually the two types of fences are complimentary to each other and their use in conjunction more effectively mitigates human-elephant conflict. Where both types of fences are deployed, whether a single community group can address aspects such as management of both fences should be determined according to the local situation. For example, when all the villagers farm a single tract. The information provided in these two chapters can be localized and adopted by specific countries for their use. With numerous illustrations and photographs, these two chapters provide information on site selection, fence location, organizing the community, on fence management and monitoring including guidelines for perception surveys among residents before and after fence installation. The guide also describes procedures for selection of fence materials and equipment. The institutional and legal implications of electric fencing were beyond the scope of this guide book.

Photo: Manali Baruah

1. Introduction

1.1. Human-Elephant Conflict

Human-elephant conflict (HEC) refers to negative interactions between people and elephants. Both elephants and people suffer from the detrimental effects of HEC. Harmful impacts on people consist of economic losses due to damage to crops and property, lost opportunity costs, psychological and social impacts, injury, and death. Harmful impacts on elephants include disturbance, psychological impacts, social impacts, injury and death, restriction of access to resources, being removed or chased from their home ranges, loss and fragmentation of range, and population extinction.

HEC mitigation is essentially mitigating the negative impacts of elephants on people. Although elephants suffer in many ways due to HEC, in general, HEC mitigation efforts do not address them. In fact, many HEC mitigation activities such as translocation, chasing, and even electric fences cause detrimental impacts on elephants.

Crop raiding by elephants is the main manifestation of HEC. Crops are species of plants found in nature but domesticated and selectively bred for thousands of years to improve their nutritional value, palatability, and ease of cultivation. Unfortunately, these same characteristics make crops extremely attractive to elephants. Elephants usually consume a high volume of low nutritional value vegetation because that is all they can find in the forest. Crops represent a resource that is many times better than what grows in the forest. The high nutritive value and palatability as well as the opportunity to gather a large amount of high-quality food in a short time, with little effort, make crops an extremely appealing resource for elephants. Harvested grain stored in houses represents an even more concentrated resource than that growing in the fields.

In general, elephants raid crops not because there is insufficient food in the forest but because crops are better. However, any decrease in the already poor resources in the forest will obviously make crops even more attractive to elephants.

1.2. Correlates of Elephant Behavior and Ecology

Adult male elephants are responsible for most crop raiding and HEC incidents, which has an underlying biological reason. Elephant social organization is different between the two sexes. Female elephants live in groups all their lives, with their offspring. Young males leave the herd and become independent at about 10 to 15 years of age. Adult males lead a largely solitary life. A female has a gestation period of close to two years and suckles the calf for about another two years. Therefore, a female comes into mating condition once every four to five years. She is in this condition for only a few days, and during that time, males in the surrounding area gather around her. There is competition between the males to mate with the estrous female, and it is thought that the strongest and biggest male wins the contest.

Therefore, for male elephants, becoming bigger and stronger is very advantageous. The way to do that is to consume lots of

high-quality food, and the highest quality food is crops grown by people. Thus, there is a strong biological drive for males to raid crops. Whether male or female, it is advantageous for any elephant to consume crops. However, because of the presence of young and risks involved in crop raiding, females tend not to raid, or raid much less often than males. When the risk is low or when they become adapted to the risk, they may also raid. Raiding by herds will likely cause much greater conflict in the future, because male calves born into such herds will take even higher risks when they become adults.

An elephant consumes approximately 100–300 kilograms of food per day. It requires around 17 hours of feeding to gather this food in the natural habitat. As crops are more nutritious than wild fodder, an elephant could obtain the same amount of nutrition from a smaller quantity of crops. However, when feeding on crops, an elephant will not go by the amount of nutrition obtained, but by the quantity consumed and is likely to consume quantities similar to when feeding on wild fodder. Also, when feeding on crops, elephants tend to trample and damage much more than is actually consumed. Therefore, the damage caused to crop fields by elephants can be extensive.

1.3. Factors Contributing to HEC Escalation

Cultivation or storage of crops in areas with elephants leads to crop raiding. Fragmentation of natural habitat by crop fields and proliferation of isolated crop fields within elephant habitat increases the overlap between elephants and crop fields, which leads to high levels of raiding and, hence, conflict. Development in a contiguous manner reduces the perimeter between crop fields and elephant habitat, and may prevent conflict escalation.

Elephants are the largest and strongest animals on land, and no other animal can challenge them physically. Many methods of preventing crop raiding, such as shouting, throwing things at elephants, or chasing elephants, are confrontational: they represent a physical challenge to elephants. When we confront elephants and act aggressively toward them, they reciprocate aggressively, and this aggressive behavior increases over time. Elephants that experience people's fear of them become more aggressive toward people, and each such encounter reinforces aggressive behavior by elephants. Aggressive elephants are more likely to raid and take greater risks. Therefore, confrontational crop protection leads to further escalation of HEC.

1.4. Approaches to HEC Mitigation

1.4.1 Separation of Elephants and People

In many parts of elephant range, limiting elephants to protected areas has been the main approach to elephant conservation and HEC mitigation. However, this has largely failed, as the increasing HEC across elephant range clearly demonstrates. Methods such as "elephant drives," used to move elephants to protected areas, have failed to eliminate elephants from drive areas and lead to increased aggression by elephants remaining behind and intensification of HEC. Separation of elephants and people at a landscape level is not an easily achievable goal, especially when there is habitat conducive to elephant presence in the designated "human areas."

1.4.2 Human-Elephant Coexistence

Coexistence between elephants and people does not mean allowing elephants access to settlements and cultivations. Elephants are naturally attracted to crops; given the opportunity they will consume them. Farmers and villagers obviously will not agree to crop consumption by elephants. Therefore, human-elephant coexistence means the co-occurrence of humans and people in the same *landscape* by prevention of crop raiding through separation of people and elephants at a fine spatial scale, i.e., at a habitat scale rather than a landscape scale. The most effective way of achieving this goal is community-based electric fencing. A coexistence model is achievable and pragmatic, benefiting both people and elephants through prevention and reduction of conflict.

2. Electric Fences

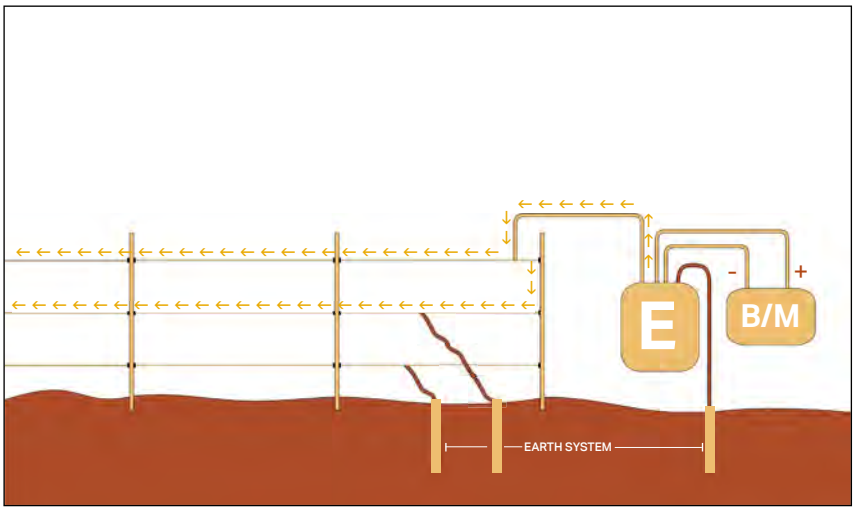
2.1. Principles of Electric Fencing

Wires on an electric fence are maintained in a charged condition. When an animal comes in contact with the charged wire, electricity flows from the wire through the animal's body into the ground, completing the circuit and giving it an electric shock (Figure 1, panels A–C). An electric shock is very unpleasant and not experienced by animals in nature. Once an elephant experiences a strong electric shock from a fence, it will keep away from such fences.

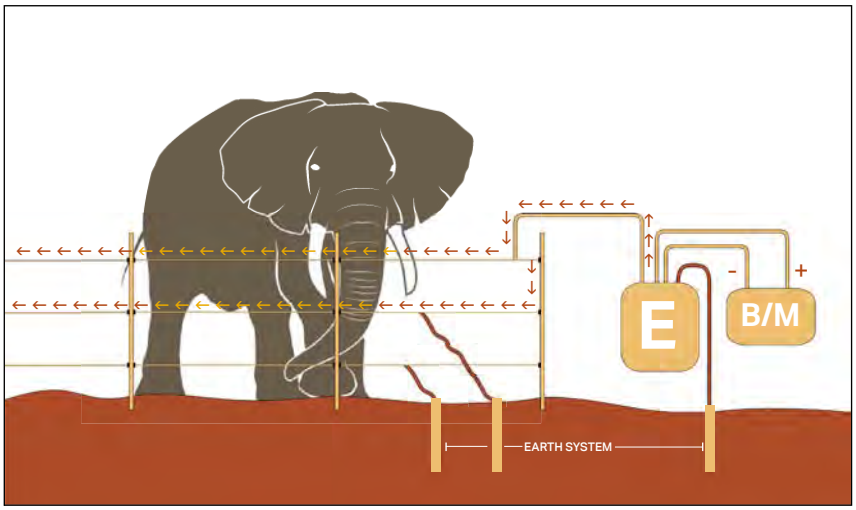
An electric fence is powered by an energizer, which runs on a 12-volt battery or mains current. The energizer converts the electricity into a high-voltage and low-amperage DC pulse at about 1 pulse per second and a pulse width (duration of pulse) of a few thousandths of a second. Fences used for elephants usually carry a voltage between 6,000 and 9,000 volts and a current of about 5 milliamperes. Touching an electric fence gives a powerful electric shock, but there is no physical harm to a person or an animal from the current. Unlike when getting shocked by household electricity, involuntary gripping of the wire and inability to let go cannot occur. However, an animal entangled in the fence and repeatedly shocked may die. Therefore, *barbed wire or concertina wire should never be used* for electric fences.

The energized parts of the fence are isolated so the current does not leak to the ground. Vegetation touching the energized parts of a fence will cause current leakage and result in the fence carrying little or no current. An elephant touching a dysfunctional fence will receive only a mild shock or no shock and will lose fear of electric fences. Such elephants are much more likely to challenge and break even well-constructed and maintained fences. Therefore, *proper maintenance is very important*. An electric fence is only a way of scaring elephants: it is a *psychological* barrier, not a *physical* barrier.

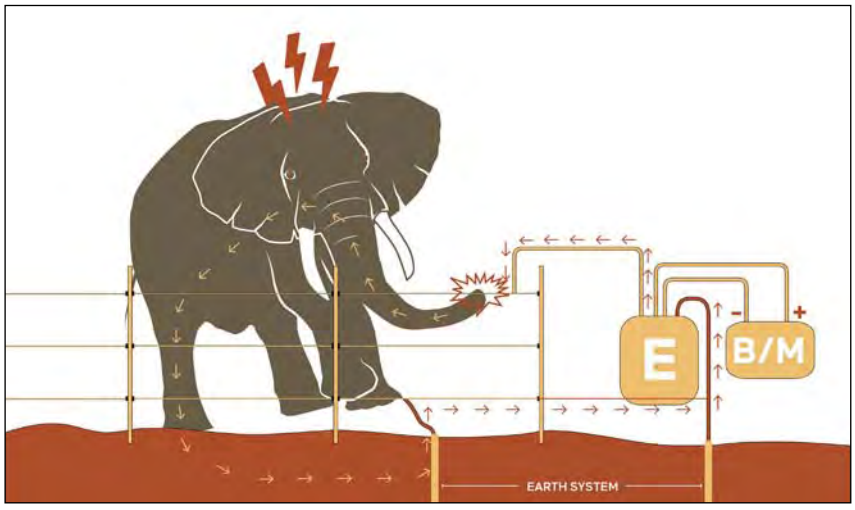
Figure 1: **Principle of an Electric Fence**



A.
An active electric fence has wires in a charged condition.



B.
Elephants are wary about approaching a fence and are likely to come up to it slowly.



C.
Upon contact with the fence, the electricity from the wire flows through the elephant's body into the ground, delivering a powerful shock.

Note: **B/M** = battery or mains current; **E** = energizer.

2.2. Approaches to Electric Fencing

Electric fences against elephants are designed as enclosure, exclosure, or linear fences. An enclosure fence attempts to contain the elephants within the area enclosed by the fence. Because elephants usually have home ranges hundreds of square kilometers in extent, enclosure fences have to be many kilometers long. Such fences are often located on the administrative boundaries of protected areas. Because of the length, fence maintenance is difficult and usually has to be done by conservation agencies. Enclosure fences have a high failure rate due to difficulties of maintenance, the presence of elephants and elephant habitat on both sides of the fence, and the absence of people residing next to the fence.

Exclosure fences are the opposite of enclosure fences. They enclose an area, attempting to prevent elephants entering it. Exclosure fences can be relatively short, a few kilometers long. Community-based fences are usually exclosure fences. Because people live close to the fence, elephants are less likely to challenge it, and it is easy for the community to do the fence maintenance. Exclosure fences tend to be much more effective in preventing elephant raiding than enclosure fences.

Linear fences attempt to restrict elephants to the area on one side of the fence. Segments of a very long enclosure fence are practically linear fences. Linear fences may also be constructed where elephant access to a human area is only across a limited stretch due to topographical or other landscape features, and the entry passage can be effectively blocked by a fence. However, it is rare to find a situation that fulfils the criteria for an effective linear fence.

Many linear and enclosure fences are entirely within or traverse long extents of natural habitat. Such fences require a person visiting and maintaining the fence as an assignment. The longer the area of natural habitat traversed by a fence, the less the likelihood of proper maintenance. Even if such fences are faithfully maintained daily, human presence at any given point of the fence is only for a few minutes a day. An elephant coming up to the fence is not concerned about the possibility of detection and has unlimited time to figure out how to break it. Therefore, fences that lie across natural habitat are very likely to be broken by elephants.

2.3. Fence Breaking by Elephants

Only a few elephants will challenge fences, and fewer learn to do it successfully. Elephants most commonly break electric fences by kicking fence posts or by pulling or pushing them with the trunk, which can be prevented by installing fence post guards (Photographs 1–3). When offset arms are used to protect fence posts (Photograph 1), they need to be designed so that the elephant cannot grab the top of the post or the arm with its trunk, without contacting the live wire (Wild Elephant 2018). Mesh fence post guards (Photographs 2 and 3) are more effective in preventing elephant damage to fence posts. Elephants may also break fences by dragging or toppling trees or branches onto the fence, which can be minimized by removing those trees from the vicinity.

Photograph 1

Wire fence post guard.

Department of Wildlife Conservation fence, Wegedera, Kurunegala District, Sri Lanka.

Photograph 2

Village fence with mesh fence post guards.

Panmedawachchiya, Trincomalee District, Sri Lanka.

Photograph 3

Village fence with mesh fence post guards on a corner post supported by two jack posts.

Tammannawa, Hambantota District, Sri Lanka.

2.3.1 Fence Breaking with Tusks

Some elephants learn to break fences by using their tusks, which are nonconducting. They may use the tusks to topple a fence post that has an off-set arm or a mesh guard (Photographs 2–3). They may also use the tusks to pull on the wires till they break.

2.3.2 Tusk Alteration

Detusking elephants has had mixed results. A trial of removing the distal third of the tusks of eight fence breaking elephants in Laikipia District, Kenya, found no detectable effect (Thouless and Sakwa 1995). In a trial in Lewa Wildlife Conservancy in Kenya, partial tusk-cutting of four fence breaking males found a sixfold reduction in damage to fences but did not eliminate fence breaking. The authors suggest that detusking could have detrimental impacts on behavior and feeding (Mutinda et al. 2014). A novel method of preventing the use of tusks to break fences was tried by A. Vipond of Knysna Elephant Park, South Africa, in which a "tusk brace" made by embedding a metal wire in a shallow groove cut in the tusks, was tried out on two males. One stopped breaking fences while the other persisted. There were also issues with the wire coming off (Palminteri 2017).

2.3.3 Fence Modification

Modifying fence design has had limited success in preventing fence breaks. As shown in the *YouTube* video in Evans (2013), guard wires that stick out of the fence along the length of the fence may prevent elephants approaching the wire. While some of the fence breaking appears to be from the "wrong side," the video also shows such fences being broken from the side with guard wires by elephants toppling the unguarded fence posts. Therefore, if such guard wires are used, fence posts should also be protected. Similarly, a hanging fence guard can be constructed with wires dangling down approximately 1.5–2 meters in front of a regular electric fence, from a high wire drawn between posts 4–5 meters tall. A hanging fence guard combined with a ground fence with the fence posts protected by mesh guards would be very difficult for elephants to break.

However, as fence complexity increases, they become more expensive, and maintenance becomes more technical and requires more effort. With increased complexity and wires, the possibility of earthing due to contact of fence elements with the ground, surrounding vegetation, or fence posts increases. Thus, there is a trade-off between fence complexity and practicality.

Because electric fences are not physical barriers and are not lethal, it is not possible to make a fence that an elephant cannot break. However perfect the fence, an elephant that learns to tolerate the shock can break it. Therefore, trying to build fences that no elephant can break may not be practical. A better approach would be to construct a fairly simple fence that is properly located, well-constructed, and maintained. The best approach to prevent fence breaking is to put fences near human presence. This decreases the likelihood of elephants challenging them and facilitates fence guarding by communities that gain protection from the fence. Elephants that break fences under these conditions are very few. Such individuals may need to be eliminated if fences are to be used as an effective HEC mitigation method in the long term.

2.3.4 Early Warning Systems

Usually an elephant will break or try to break a fence a few times and will move away. If fence breaking becomes a problem, fence guarding—by setting up watch posts, campfires, and lanterns along the fence line—can be a deterrence. Setting up an early warning system consisting of a trip wire connected to an alarm, located a few meters outside the fence, may also help. Such early warning systems can be simply a wire with dangling tin cans and bottles that jingle when the wire is moved or technologically advanced with motion detectors connected to lights and alarms. An early warning system greatly facilitates fence guarding, making it more effective and enabling significant reduction of effort in guarding.

3. Community-Based Village Electric Fences

Raiding of home gardens and houses by elephants is a major cause of HEC. In addition to economic losses, the threat of such raids and their unpredictability may cause severe socioeconomic issues. Attempting to prevent raiding by confronting elephants that enter settlements may result in injury and death of people and elephants. It may also promote aggression of elephants toward people, leading to continued escalation of HEC. Community-based electric fences that protect settlements can bring immediate relief from HEC to affected communities and are an effective and sustainable intervention.

Fence construction is only part of a community-based fencing program. To be successful, community-based fences require community engagement and a long-term commitment by implementation agencies. If such engagement or commitment is not possible, the program should be implemented through an agency that can comply with the requirement. Simply constructing an electric fence around a village or crop field and handing it over to the community concerned, or maintaining it by the implementation agency, is likely to lead to failure. Failed fences expedite learning of fence breaking by elephants, which leads to the inability of using electric fencing as an effective deterrent over a wider area. Thus, half-hearted attempts at community-based electric fencing may do more harm than good in the long term.

Note: For this guide, conservation agency means an entity whose primary mandate is conservation; in contrast to other entities with a mandate to support human welfare and development issues. Implementation agency means an entity working with the community to help establish the community-based electric fences.

3.1. Village Selection for Community-Based Fences

Community-based electric fencing is not a solution to all HEC problems. However, given that the main cause of HEC is crop raiding by elephants, it can be effective in many HEC situations. A few criteria are important in determining whether a particular village or settlement is suitable for implementing a community-based electric fencing program.

3.1.1. Community Considerations

- Since the effectiveness of a community-based electric fence is largely dependent on the community, an assessment should be made whether the fence is necessary (see Annex 3A for a sample questionnaire).
- Indicators are extent, frequency, and seasonality of damages caused by elephants and the economic loss incurred. Lost opportunity costs and psychosocial impacts are additional indicators. As much as actual damage, whether the community perceives raiding by elephants to be a major problem is important.
- After learning about community-based electric fencing, the community should be keen to embrace it to help themselves overcome HEC and be willing to accept the conditions of providing a fence.
- Any group of people who identify themselves as separate from other such groups for social, ethnic, religious etc. reasons ideally should have an independent fence or fence segment. This would foster ownership and prevent fence failure due to inability or disinclination to work as a unit.

3.1.2. Geographic Considerations

An exclosure fence is the most appropriate design for a community-based village electric fence. Therefore, an assessment needs to be made if it is possible. A community-based village electric fence should (a) enclose only the settlement area (houses and home gardens with permanent cultivations); (b) be at the boundary of natural habitat and currently used land; (c) not enclose any seasonally cultivated land within the fence; and (d) not enclose any natural habitat patches within the fence. Note that if there is seasonally cultivated land near the village, in addition to the village fence, a seasonal fence can be constructed during the cultivation season (see chapter 4).

3.2. Fence Location

The cardinal principle of an electric fence is that there can be elephants only on one side of it. One main requirement is the absence of elephant habitat on the other side of the fence. Elephant habitat is any sizable area of natural habitat. If there is elephant habitat on both sides of a fence, it is likely to have been previously contiguous elephant habitat. Elephants will break such fences to use familiar areas that were previously part of their home range. If there are elephants on both sides of a fence, it is a failure. Failed electric fences should be removed: they serve no purpose and their persistence encourages elephants to learn to break them (Photographs 4a and 4b) making electric fencing obsolete over a large area.

Photographs 4a and 4b

Elephant calf playing with a nonfunctional fence: such exposure and learning is likely to lead to breaking of functional fences.

Yala, Hambantota District, Sri Lanka.

If there is natural habitat that provides cover to elephants adjoining an exclosure fence on the inside, an elephant coming up to the fence will not be noticed by people. In contrast, if the entire length of the fence can be seen from within the village, an elephant approaching and trying to break the fence is likely to be seen and chased away. Similarly, an elephant approaching a fence with natural habitat adjacent to and inside the fence will not see people and is free to spend a long time figuring out how to break it, because it does not feel exposed or fear detection. Regardless of the design, such fences are likely to be broken by elephants. Therefore, it is very important that lands enclosed within a community-based fence do not have natural vegetation that provides cover for elephants. A simple way to explain it to communities is to say that the fence should be visible at night when a flashlight is shined from within the protected village.

One of the main reasons community-based electric fences tend to be less challenged and broken by elephants than fences erected on boundaries of protected areas is the regular presence of people next to the fence. Therefore, in designing a community-based fence, areas not used regularly by people have to be excluded.

If elephant intrusion to the village is only in the night, spaces used only during the day, such as places of worship, playgrounds, and community meeting areas, need not be included within the fence. Such exclusion is particularly important if these places are separate from the village or are located at the periphery and prevent sighting of elephants coming to the fence from within the main village area. Similarly, seasonally cultivated plots should not be included within a community-based village electric fence, because people will not maintain the sections bordering such fields when they are not cultivated.

Protecting large-scale cultivations such as tree plantations, sugar cane, or oil palm with electric fences is less effective than community-based fences because of the absence of people living nearby. Such plantation areas should not be included within a community-based village electric fence.

When the idea of a community-based fence is proposed, villagers may desire to enclose a large area, either consisting of all land owned by them or additional land they want to acquire. However, enclosing land not currently in use within an exclosure fence drastically decreases its effectiveness. Therefore, the community should understand that a community-based electric fence is strictly for protection from elephants and should never be used as a boundary marker. Having the community—rather than an external agency—construct the fence facilitates buy-in of the concept. Since the community gains technical capacity in fence construction, members can alter the fence line in the future if additional land is developed.

If the community is concerned that the fence will be considered a boundary by authorities and that they will lose ownership of land outside, the matter needs to be sorted out with the appropriate stakeholders. Making the relevant authorities part of the implementation process facilitates resolution of such issues. Locating the fence at the boundary of land currently used is greatly facilitated by individual villager's contribution to fence cost, in proportion to ownership of land area protected by the fence. This is because people usually do not want to pay for currently unused land.

In summary, community-based village electric fences are for protecting home gardens, houses, and people. A fence is effective only if it is close to what it is meant to protect. Therefore, community-based electric fences should be erected only on the ecological boundary for elephants, which is the perimeter of the village area in constant use by people (Figure 2).

Figure 2

Plan of village electric fence, drawn using GPS positions and Google Earth. Mannakkuliyagama, Kurunegala District, Sri Lanka.

3.3. Fence Management

The success of an electric fence is largely dependent on maintenance, which is the primary focus of fence management. Electric fence maintenance is simple: the main actions are preventing any plants from germinating under the fence growing up to a meter and touching the wires, lopping off any branches that may touch the fence, and correcting any faults or damages.

Clearing vegetation and inspecting the fence for any breakages should be done periodically. The frequency of inspection (see section 3.4.3) should be determined based on the rate of growth of vegetation causing current leakage and how often fence faults or damages occur. The more frequently a fence is inspected, the more likely that it will function without any issues. Inspection and maintenance are simple for someone living next to a fence. For a person cultivating a home garden by preparing soil, planting, tending and harvesting, maintaining a few meters of fence bordering the garden takes little effort or time. For an employee of an external agency to come from outside and maintain a fence that is protecting a village—while those living next to the fence and are protected by it do nothing—makes little sense. Fences managed by external agencies are also likely to be damaged by people for trivial gain or ease, such as cutting wires or not replacing a gate wire when crossing a fence.

Fence management by outside agencies is likely to fail for many reasons, and it dissuades development of a sense of fence ownership by those protected by the fence. In contrast, community management of fences is easy, simple, of little cost, sustainable, and fosters a sense of ownership. Since an effective community-based fence directly benefits the community, it is in the community's best interest to manage it well. Similarly, mismanagement resulting in fence failure directly impacts the community, and they must bear the blame for it.
If a fence fails because it is not located properly or is not maintained properly by the community, all efforts should be made to rectify the problem. However, if it cannot be made to function effectively for whatever reason, the fence should be removed, as a non-functional fence does not provide any protection and will only promote learning of fence breaking by elephants.

3.4. Community Organization

If a strong community organization exists in the village, it could be co-opted for the task of fence management. If not, a fence committee needs to be set up, whose main task is managing the fence.

3.4.1. Fence Committee Members

The fence committee should have a number of office bearers such as chairman, secretary, and treasurer, and about five members. All should be elected from among the residents of the village.

3.4.2. Fence Committee Responsibilities

The tasks include coordinating the processes of establishing the fence, fence maintenance, collecting funds, setting up and maintaining a fence maintenance fund, and holding monthly meetings and annual elections. The committee should draw up a constitution detailing the responsibilities and processes for achieving the above. The fence committee should inform the villagers about the work required for each step in fence establishment and assign individuals for the tasks.

3.4.3. Fence Maintenance

The fence committee should determine the maintenance procedure and schedule. Communities have successfully adopted different mechanisms for fence maintenance, such as: (a) daily fence inspection and maintenance by assigned villagers based on a roster; (b) communal maintenance in which regular monthly dates (such as the first and 15th of each month) is set for fence maintenance; (c) allocating responsibility for maintaining segments of fence to individuals; and (d) collecting funds from the community and employing personnel to maintain the fence. Proper maintenance is facilitated by an effective penalty, such as a fine levied by the fence committee for nonparticipation or not completing allotted tasks.

3.5. Community Financial Contribution

The higher the monetary investment by the community, the greater its sense of ownership and the likelihood of good maintenance, effectiveness, and long-term sustainability of the fence. Monetary investment by the community consists of contribution to the fence cost and for fence maintenance.

3.5.1.Contribution to Fence Cost

The contribution to fence cost is a one-time event. The amounts to be contributed by individual households are determined based on the extent of their land protected by the fence. A standard amount per unit of land is determined in consultation with the villagers, based on their ability to pay. If the villagers are unable to assess the amount of land they own, GPS mapping of individually owned plots within the proposed fence line could be done and the extent calculated by inputting the GPS locations to Google Earth, drawing a polygon, and assessing the extent. A listing of individuals, extent of land, and contribution amount is drawn up and displayed publicly. Individual households, whose poor financial situation precludes contribution to fence cost at present, could be provided with a loan facility, or the rest of the villagers could donate to cover their contribution.

3.5.2. Contribution to Fence Maintenance

The contributions are periodically collected, usually monthly for village fences. Usually a flat rate is levied per household. The amount to be collected is determined in consultation with the villagers, based on their ability to pay. The amount collected should be sufficient to develop a fund that will be able to cover repairs to the fence and fence components such as fence posts in the short term, battery in the midterm (two years on), and energizer, solar panel, and wires in the long term (five years on). When the handling of community generated funds by the implementing agency is not possible because of internal constraints (as in government agencies), the fence committee should collect the same amount of funds as for contribution to fence cost and use it to establish the fence maintenance fund to which the fee levied monthly would be added.

A transparent process of managing the finances is important, with maintenance of books, guidelines for fund withdrawal, and regular presentation of accounts to the community. If an existing organization is co-opted for fence management, it is advisable to set up a separate account for the fence.

If communities do not have the capacity to maintain accounts, capacity development needs to be part of community engagement by the implementing agency.

3.6. Community Labor Contribution

The community should provide the entire labor required for constructing and maintaining the fence. Community members should not be paid by the implementing agency for their labor, because it strongly advocates fence ownership by the agency and not the community. A number of activities in fence construction—such as clearing of land enclosed by the fence, clearing and preparing the fence line, digging fence post holes, construction of energizer hut, planting fence posts, and stringing the wire—require labor (as do fence inspection, clearing, and repairs for fence maintenance). Individual householders who cannot participate could provide personally hired labor to replace them. Some activities, such as clearing the fence line, could be done manually or by hiring a bulldozer or excavator. If the community opts for such activities, the fence committee or other party should collect funds for it and bear the extra cost.

In allocating labor or collecting additional funds, the community should decide whether to do it in proportion to extent of land included within the fence owned by a household or to divide equally among households. Coordination of these activities and their supervision is the responsibility of the fence committee.

3.7. Fence Monitoring

The completed fence should be monitored weekly for a minimum of one year. After one year, if the fence is being maintained well, monitoring frequency can be reduced to once a month. An officer from an external agency (usually the implementation agency) and an assigned community member (the fence committee assigns a villager based on a roster) monitor together. The entire fence line is walked and the voltage checked at 100-meter intervals using a voltmeter. Problems such as vegetation touching the wires, wire touching the ground, loose wires, or posts at an angle are noted in respect to the numbered posts (see annex 3B for fence monitoring form). At the same time the assigned community member is shown the defects. The community member informs the fence committee, and the deficiencies need to be corrected immediately.

3.8. Implementation Agencies

Community-based electric fencing is entirely for protecting communities from elephant depredation. Therefore, from a philosophical point of view, whether conservation agencies should bear the responsibility for implementing community-based fencing programs is questionable.

3.8.1. Human Resources

To be effective at HEC mitigation over a landscape scale, community-based fences have to be small and numerous. Each fence requires community engagement for an extended period of time for its deployment and needs to be monitored regularly once completed to ensure success.

Where conflict is widespread, conservation agencies rarely have the human resources to contend with the numbers of community-based electric fences required to make a real impact on HEC mitigation at a landscape scale. However, agencies whose main responsibility is people's welfare and

development are numerous and ubiquitous in any country. These agencies tend to have extensive networks based among the people. They are likely to have a much better relationship with communities than conservation agencies and have authority over the people. Therefore, they are far better positioned than conservation agencies to implement community-based fencing programs. If agencies whose main focus is people's welfare and development implement community-based fencing, the scale of human resources is not an issue.

3.8.2. Funds

To be effective at a landscape scale, community-based electric fencing requires a much greater investment in funds than an approach of limiting elephants to protected areas by electric fences. In most cases, conservation agencies do not and will not have access to the scale of funds required for an effective community-based fencing program at a landscape scale. This is particularly the case where conflict is widespread. In contrast, agencies responsible for people's welfare and development have access to greater funds. If such agencies implement community-based fencing programs, funding is not an issue.

The appropriate agencies for implementing community-based electric fencing are not conservation agencies, but administrative and development agencies. However, because traditionally HEC mitigation has been the preserve of conservation agencies, it may be difficult to effect such a paradigm change immediately, and conservation agencies may need to implement a few community-based fences as examples. Where conflict is limited, conservation agencies maybe able to implement such programs fully.

3.9. Personnel Implementing Community-Based Fencing Programs

To ensure success of a community-based fencing program, it is best to identify a group of people who will carry out such programs and train them. Personnel implementing a community-based fencing program should have the following:

- A clear idea of the objectives of community-based fences and the rationale behind it.
- Ability to work with communities including conducting awareness programs, community organization and motivation, and settling disputes.
- Expertise in use of GPS units and Google Earth.
- Knowledge of the components of an electric fence and their function.
- Ability to estimate fence material quantities and their purchase.
- Experience in installing electric fences.
- Experience in monitoring and maintaining electric fences.

While this guidebook provides direction, personnel involved in implementing a community-based fencing program need to have practical training in setting up electric fences. Where conflict is limited, conservation agencies maybe able to implement such programs fully.

3.10. Selection of Fence Materials and Equipment

Always use good quality components. Cheap components are likely to fail, last a much shorter length of time, and therefore need frequent replacement (hence, in the long term they will cost more). Remember that it is better to construct one expensive fence that works properly than two cheap ones that do not!

A brief introduction to the main components and their use in the context of village fences against elephant depredation is provided here. For detailed accounts of each component and its installation, please refer to manuals available from electric fence material suppliers.

3.10.1. Fence Posts

Fence posts can be made of reinforced concrete, wood, or GI (galvanized iron). Generally concrete or wooden posts are used for permanent fences. The live wires have to be isolated from all of them by the use of insulators.

Concrete posts, once broken by an elephant, cannot be reused and have to be replaced. Wooden posts could be reused because the post usually topples without breaking, while GI posts may be bent back or cut and re-welded if bent. With very hard ground, wooden posts may also break. Concrete posts work well in most situations and are usually the cheapest option.

GI posts have a disadvantage in that any live wire touching the post completely grounds the fence, making it nonfunctional. Energizing the post as in seasonal agriculture fences (see chapter 4) is not recommended for a permanent village fence because damages to fence post ground insulators tend to accumulate and cause significant current leakage over the long term unless the fence is frequently checked and very well maintained.

Fence posts should be 250 centimeters tall. After they are buried 60 centimeters in the ground, their standing height is 190 centimeters. The height of the fence post (and wires) may have to be increased if elephants manage to step over the fence at these measurements. Wooden and GI posts need to be drilled and concrete posts fabricated with holes for the wire inserts.

3.10.2. Post Guards

Fence posts can be protected from kicking and from pulling with the trunk by elephants through installation of a length of GI mesh that covers the fence post and is attached to the live wires (Photographs 2–3). A square is cut out from the mesh centered on each reel insulator, and the wires and mesh are offset from the post by inserting the reel insulator clip through an 8-centimeter piece of 40-millimeter PVC tubing (Photograph 5) to prevent earthing of the mesh guard to the post. Fence guards such as dangling wires can also be used, but usually the mesh guards are sufficient for village electric fences.

Photograph 5

Close-up of fence post with mesh guard, showing details of assembly.

Eruwewa, Anuradhapura District, Sri Lanka.

3.10.3. Wire

Heavy galvanized high tensile steel wire 2.5 millimeters thick should be used for permanent village fences. Three strands of wire should be used. The top wire should be located close to the top of the post, and the two bottom wires should be 60 centimeters and 120 centimeters from the top wire, respectively.

Since village fences are comparatively short, three live wires can be used where the ground is reasonably moist. Where the ground is very dry and hence conductivity is low, a fourth wire could be added as an earth wire, tacked onto the fence posts below the lowest live wire and connected to GI earth rods at intervals along the fence. If an earth wire is incorporated in the fence design, the community should be well versed in its function and clearly understand that it should never be connected to the live wires, because that will make the fence nonfunctional.

3.10.4. Lead-Out Cable

Insulated high tensile heavy galvanized steel wire, equal to or greater in diameter than the fence wire, is used to (a) route the current underground at gates, (b) connect the earth terminal to the earth, and (c) conduct current to the fence from the energizer. Insulated household wire or cables made of other material such as copper should not be used because using different metals in the electric circuit leads to electrolysis and rapid corrosion of some components.

3.10.5. Gate Springs

Gate spring and handle units can be purchased from fence material suppliers or fabricated using the fence wire and a length of PVC tubing.

Insulators

Reel and strain insulators are needed. Reel insulators connect the wire to the fence post, and strain insulators are used at corner posts and gateposts. High-quality insulators such as porcelain or UV- stabilized plastic are preferred because they last many years.

3.10.6. Wire Tighteners and Tension Springs

Wire tighteners and tension springs are installed, one for each strand, for each span of the fence. They facilitate tensioning the different strands of wire to the same extent. However, wires should be tensioned only so that they do not sag and not until they are taut.

3.10.7. Joint Clamps

Use joint clamps to splice wires together rather than tying them, because it will give a better connection.

3.10.8. Energizer

Many situations where a village fence is indicated may not have mains electricity. Therefore, an energizer that works off a 12-volt battery current could be used. In case mains current is available and an energizer powered by mains grid electricity is used, make absolutely certain that everybody involved understand that the mains current should never be connected to the fence directly, and it should only be used to power the energizer. Connecting mains current to the fence is illegal and creates a lethal fence that will kill persons or animals touching it. If there is any doubt about the reliability of the community, *do not install* a mains-powered energizer.

An energizer with an output joule rating above 3.5 joules (stored joule rating above 5 joules) should be used. When connected to the fence it should maintain a voltage above 6,000 volts. An energizer with an integrated alarm is preferable. Such units sound a loud alarm when a voltage drop occurs as when the live wire is broken and grounded or the battery current drops. More advanced models can also sound an alarm when an animal contacts the wire.

3.10.9. Earth System

A good earth system is a must for the functioning of an electric fence. It is usually close to the energizer, ideally where the ground retains moisture throughout the year. About five galvanized steel rods are driven into the soil to 1.5 meters in depth, spaced 3 meters apart and connected to each other in series and to the earth terminal of the energizer with an insulated cable. The cable should be connected to the rods with clamps (taking the insulation off of the cable at the point of contact). Refer to the manuals from parts suppliers for proper installation of the earth system. Earth rods used for the earth system of houses are usually copper plated and should not be used because the different metals in the electric circuit will lead to electrolysis and rapid corrosion of some components.

3.10.10. Energizer Hut

The energizer hut can be made out of bricks and mortar, similar to an outhouse, with sufficient room to store fence material and supplies (Photograph 6). Or it can be built as a small cabin, which has just sufficient room for the energizer, controller, and battery (Photographs 7–8). An energizer should not be housed inside a hut or other living quarters.

Photograph 6
Energizer hut.
Tammannawa, Hambantota District, Sri Lanka.

Photograph 7

Energizer cabin.

Panmedawachchiya, Trincomalee District, Sri Lanka.

The energizer hut or cabin should be close to the fence and to the earth system. If it has to be located some distance from the fence, the electricity should be conducted to the fence along an insulated lead-out cable. In a linear fence, the energizer should be close to the midpoint of the fence so the fence is split into two sections on either side of the energizer. This facilitates fault finding because each section can be independently switched off. Because an exclosure fence conforms to a circle, the energizer hut can be placed at any point. However, the fence still should be split into two sections, with the two sections isolated from each other at a point diagonally opposite the energizer placement.

Photograph 8

Energizer cabin showing installed components.

Galgamuwa, Kurunegala District, Sri Lanka.

3.10.11. Battery, Controller, and Solar Panel

If special batteries for electric fences are available, they would be ideal. However, an automotive 12-volt lead acid battery is adequate. It is preferable to use a sealed battery so that regular battery maintenance is not required and its lifetime is longer. If a non-sealed battery is used, instruct the fence committee on battery maintenance and include it in the maintenance schedule.

The required battery size (amperage) will depend on the model of the energizer. The controller and solar panel required will depend on the battery. The solar panel needs to be cleaned at intervals determined by environmental conditions such as dust deposition on the panel. Follow the manuals from the supplier or get expert help for aligning the solar panel to the sun and installation of the controller and battery.

3.10.12. Lightning Diverters

Connect the fence to lightning diverters so that any lightning striking the fence is conducted to the earth system and does not destroy the costly energizer.

3.10.13. Fence Indicator Light

Fence indicator lights that illuminate when the fence is charged can be installed at intervals along the fence. While not essential, they will alert people along the fence when the fence is activated.

3.10.14. Warning Signs

Sign plates with a warning that this is a high-voltage electric fence should be installed on fence sections traversing community areas.

3.10.15. Implements

- **Wire dispenser**. Used when constructing the fence to give out the wire.
- **Wire cutting pliers**. Special pliers are available from electric fence material suppliers that make handling and cutting of the wire easy. High tensile steel wires are difficult to manipulate using household pliers.
- **Wire tightener handle**. Available from electric fence material suppliers for adjusting the wire tighteners.
- **Voltmeter.** A voltmeter compatible with the energizer is required to check voltage, detect leaks, and monitor the electric fence. The fence committee and the monitoring agency should each have one. It is preferable to get the voltmeter from the same supplier as the energizer to ensure compatibility.

3.11. Required Materials

Table 1: Required Materials for Fence Building

#	DESCRIPTION	QUANTITY
	Material used once in a fence	
1	Energizer	1
2	Lightning diverter	2
3	Alarm with siren and strobe light (compatible with energizer)	1
4	Cut-out switch	2
5	Earth rod (length: 2 m / hot dip galvanized)	7
6	Earth rod wire clamp	7
7	Solar Panel (100 W) and mounting kit set	1
8	Solar charge controller (20 A)	1
9	Lead acid battery (120 A)	1
10	Energizer cabin or hut	1
11	PVC pipes (diameter: 20 mm)	10 m
12	PVC bend sockets (diameter: 20 mm)	20
13	Insulated lead-out cable (diameter: 2.5 mm)	80 m

#	DESCRIPTION	QUANTITY
	Material for 1 km of fence line (multiply by fence length in km)	
1	Reel (bobbin) insulators	198
2	Reel insulator clips (long)	198
3	High tensile heavy galvanized steel wire (diameter: 2.5 mm)	3,200 m
4	Fence middle posts (height: 250 cm)	66
5	5 x 5 cm GI wire mesh (post guard) (pieces: 210 x 30 cm)	66
6	Heavy-duty PVC pipe (40 mm)	6 m
7	Warning sign boards	5
	Add for each span	
1	Strain (bull-nose) insulators	6
2	Joint clamps	6
3	Wire tighteners	3
4	Wire tension springs	3
5	Fence corner posts (height: 250 cm)	1+ no. of spans
6	Jack (support) posts (height: 250 cm)	1 or 2 per corner post [a]
7	5 x 5 cm GI wire mesh (post guard) (pieces: 210 x 30 cm)	2 or 3 (1 per post)
8	Reel (bobbin) insulators	3 or 10 [a]
9	Reel insulator clips (long)	3 or 10 (1 per reel insulator)

a. Depends on the angle of fence change between spans. If the angle is less than 90 degrees, the jack post is inside the fence and does not need a guard. If it is 90 degrees, two jack posts are required along the spans, and the jack posts and the corner post require guards (Photograph 3/*page 17*).

#	DESCRIPTION	QUANTITY
	Add for each gate	
1	PVC pipe (diameter: 20 mm)	10 m
2	PVC bend sockets (diameter: 20 mm)	6
3	Insulated lead-out cable (diameter: 2.5 mm)	10 m
4	Gate spring kit	1
5	Strain (bull-nose) insulators	6
6	Joint clamps	6
7	End strain (corner) posts (height: 250 cm)	2
8	Jack (support) posts (height: 250 cm)	2
9	5 x 5 cm GI wire mesh (post guard) (pieces: 210 x 30 cm)	4
10	Reel (bobbin) insulators	10
11	Reel insulator clips (long)	10
Sufficient quantities of cement, sand, and metal for concreting bases of corner, gate, and jack posts		

The actual quantities of material need to be calculated according to above guidelines in Table 1. Changes in the number of wires, addition of an earth wire, use of different fence guards, and so on will require changing quantities accordingly.

3.12. Cost of Fence Material

In general, the cost of fence material for a permanent village electric fence of around 5 kilometers will be around US$4,000 to US$5,000 per kilometer, or around US$20,000 to US$25,000 total (as estimated on prices in Sri Lanka in 2019).

- Of this, the main cost is for fence posts, which will be about 30 percent to 50 percent of the total.
- Cost of wire (three live and an earth strand) and lead-out cable will be around 20 percent to 25 percent of the total.
- Energizer, solar panel, and controller will cost around 3 percent to 5 percent of the total.
- Other components will make up the balance.

The main expense in fence material is for components along the length of the fence (posts, wire, and so on). Components needed only one per fence, such as the energizer and battery, make up only a small percentage of the total cost. The longer the fence, the lower the contribution of these items to the total per kilometer cost of the fence. Obtaining low-cost units that are likely to be of low quality for one only component does not make much difference to the total cost, but may have a major negative impact on fence function.

3.13. Assessing Fence Effectiveness

3.13.1. Monitoring Records

The data recorded during the weekly monitoring provide a good indicator of the effectiveness of a fence (Annex 3B). Recording of elephant signs adjacent to the fence shows the presence of elephants that may have entered the village if not for the fence. If there are any fence breakages by elephants, their increase or decrease with time indicates the long-term viability of the fence.

3.13.2. Surveys

Community surveys before the establishment of a fence and about a year later provide good indicators of the effectiveness of the fence (see Annex 3C). However, results may need to be interpreted based on other environmental variables that may have an impact on crop raiding by elephants. A questionnaire can be administered to all the houses or a random sample depending on the size of the village. Questionnaire surveys can be used to assess the income gained from cultivation and losses experienced within the fenced area by villagers before and after fence installation (See Annex 3A and 3C). Perceptions and attitudes of the villagers toward elephant intrusion into the village, HEC and its management, elephants, and elephant conservation are also useful indicators of the impacts of the fence.

Comparison with villages protected by community-based fences and those that are not in the same area provides another viewpoint. However, because of influence of many factors other than the fence on HEC, such comparisons would be useful only with a large number of protected and unprotected villages. Indicators such as the number of elephant and human deaths are not valid parameters for assessing effectiveness of community-based fences because of the rarity of such events at a relevant scale and the varied (not fence-related) reasons for their causation.

3.14.Guidelines, Activities, and Protocols

Following is a suggested step-by-step procedure for establishing a community-based village electric fence. It may need to be adapted according to local requirements and conditions.

Step 1

Objective: Assessing suitability of location

Community considerations: Questionnaire survey of households (Annex 3A), discussions with community leaders, and secondary data from relevant agencies can indicate whether a particular community experiences significant HEC and are keen to adopt community-based electric fencing for its mitigation (see section 3.1).

Geographic considerations: Taking a few GPS positions with a handheld unit and seeing the proposed location on Google Earth provides an assessment of whether a location is likely to fulfill the geographic criteria for a community-based fence (see section 3.1).

- If both community and geographic criteria appear to be fulfilled, introduce the idea of community-based electric fencing to a few community leaders and assess interest.
- If positive, they should organize a meeting in which specifics are explained to the entire community.

Step 2

Objective: Awareness program

Participants: Entire community

Material: Multimedia projector, laptop computer, presentation on electric fencing, screen

Activities:

- Discuss problems the community has had with elephants, how often damages occur, whether it is seasonal or year-round, what they are currently doing to prevent raiding, and the success of current practices.
- This can be followed by a presentation about electric fencing.

Specifics to be explained:

- Community-based electric fencing can help communities overcome raiding by elephants to a large extent.
- A community-based electric fence brings immediate relief from elephant raiding.
- The community can be helped to obtain relief, but it is not something that someone else can do for them.
- How an electric fence works (see section 2.1).
- Difference between enclosure, exclosure, and linear fences (see section 2.2).
- Community-based electric fences (see section 2.2).
- Approximate cost of electric fencing (see table 1, section 3.11).

- Conditions of providing assistance to construct an electric fence
    - Introduce community contributions to cost, construction, and maintenance
    - Fence management (see section 3.3)
    - Circumstances under which the fence will be removed (see section 3.3)

After the presentation, the community is given one to two weeks to discuss what has been presented and to make a decision (Photograph 9).

Photograph 9
Community meeting. Panmedawachchiya, Trincomalee District, Sri Lanka.

Step 3

Objective:

Election of fence committee

Determination of contribution to fence cost

Initial fence line demarcation

Participants: Entire community, representatives of relevant authorities (administrative or conservation sector, etc.)

Timeline: Two to four weeks after step 2

Material: Handheld GPS, spray paint can

Activities:

At the community meeting the following should be addressed:

- Clarifications or concerns of the villagers regarding the program
- Fence committee (see section 3.4)
    - Description of responsibilities and tasks
    - Composition
    - Election of office bearers

- Financial contribution toward fence cost (see section 3.5)
  - Rationale for contribution in proportion to land ownership
  - Determine contribution amount per unit of land
- Initial fence line demarcation
  - Explain rationale for excluding unused or unoccupied land (see section 3.2).
  - Walk along proposed fence line with community and demarcate by spray paint (Photograph 10) on vegetation or by planting stakes every 20 meters.
  - Take GPS positions every 50 meters and at any change of direction.
  - Emphasize to community members that they will need to walk this line regularly for fence maintenance; hence they should have it at the edge of used land.
  - Set date for finalizing fence line (one to two weeks).

Photograph 10
Discussing and marking the fence line.
Tammannawa, Hambantota District, Sri Lanka.

Interim of Steps 3 and 4

- Assess proposed fence line by locating it on Google Earth using the GPS points obtained in step 3 (Figure 2/*Page 23*).
- Calculate length of fence and area covered.
- Determine any changes needed to the fence line (e.g., for excluding natural habitat or unoccupied plots).

Step 4

Objectives:

Finalizing fence line

Decide on individual fence cost contributions

Fund collecting

Land clearing

Participants: Entire community

Timeline: One to two weeks after step 3

Activities:

- Project Google Earth image with proposed fence line (see Figure 2/*Page 23*).
- Discuss any changes that need to be made.
- If agreement is not reached on the fence line, ask community to inform when agreement is reached. If there are proposed changes, call an additional meeting to finalize the fence line.
- If agreement is reached on the fence line, determine if the community has knowledge of individual ownership extent of each enclosed plot of land. If not, set date for GPS mapping of individual plots.
- Fund collection: once the fence line is finalized, the fence committee should set up a bank account, prepare the list of households, collect funds (to deposit in bank account or to hand over to implementing agency) (see section 3.5).
- Land clearing: explain the need to see the fence from within the village (see section 3.2) and set a date for completion of clearing any obstructing vegetation within the area to be enclosed by the fence.

Interim of Steps 4 and 5

- If required, GPS mapping of individual plots, determination of extent of land and finalizing the list of individuals, land extent, and amount to be paid by each household.
- Fence committee collects funds for contribution and deposits in dedicated account or hands over the funds.
- Clearing of land within the fence line.

Step 5

Objective: Inspection of land clearing

Participants: Fence committee

Timeline: Upon completion of fund collection and land clearing

Activities:

- Walk the fence line with the fence committee and inspect if land clearing is adequate.
- If not, instruct it to be completed by set date for proceeding with the fence.

Land that has been cleared just for this purpose would need to be maintained in a cleared state from then on. If clearing is not done at this stage, it is highly unlikely that such plots will be cleared and maintained. Therefore, it is best to exclude them from the fence, which would result in changing of the fence line. If that is not possible, discuss with the fence committee what arrangements they can make to ensure clearing and maintenance.

Step 6

Objective: Demarcation of fence line

Participants: Fence committee, sufficient helpers, community (relevant community members)

Timeline: Upon confirmation of adequate land clearing

Material: Handheld GPS, spray paint can, adequate number of stakes

Activities:

- Map the fence line by walking along edge of the cleared area with a handheld GPS unit.
- Take GPS positions every 50 meters and at any point there is a change of direction.
- Mark the line with spray paint on vegetation or by planting stakes every 10 meters.
- Instruct fence committee on specifications of clearing (3 meters on either side of demarcated line). The strip should be cleared of all vegetation and reasonably levelled (Photograph 11). Large rocks, termite mounds, and so on should be avoided or removed.
- Set a date for completion of clearing the fence line.

Photograph 11
Clearing the fence line.
Bundala, Hambantota District, Sri Lanka.

Step 7

Objective: Inspection of fence line clearing

Participants: Fence committee

Timeline: Upon informing of fence line clearing

Activities:

Walk the fence line with the fence committee and inspect if the fence line clearing is adequate. If not, instruct it to be remedied and set a date for proceeding with the fence.

Step 8

Objective: Marking of fence post positions

Participants: Fence committee and sufficient helpers

Timeline: Upon confirmation of adequate fence line clearing

Material: Adequate number of stakes

150-meter cord marked every 15 meters with knots or tape

Wrapping the cord on a reel so that it can be played out is useful (Photographs 12–13).

Photograph 12

Laying down the cord to mark the fence post holes.

Mudaliyarkulam, Trincomalee District, Sri Lanka.

Photograph 13

Aligning the cord in the center of the cleared strip for marking the fence post holes.

Mudaliyarkulam, Trincomalee District, Sri Lanka.

Activities:

- Walking the fence line, position the marked cord in the middle of the cleared area so that each segment of the fence conforms to a straight line.
- Mark fence post positions by planting stakes at each 15-meter marking and at all points where the fence line changes direction.
- Take count of types of posts (corner posts, gate posts, jack posts). A corner post has to be placed at every point the fence changes direction, gate posts flank each gate, and corner posts and gate posts have to be supported by jack posts so that the pull by the wire is resisted by the jack post).

- Count the gates. Each entry to a household and road crossing requires a gate. The width of the gate is determined by what needs to go through (vehicles). Gates add considerably to the fence cost. Gates left open provide entry to elephants. Therefore, design the fence to minimize the number of gates and locate gates so villagers can easily observe and manage them.
- Instruct fence committee on dimensions of fencepost holes: 40 by 40 centimeters, centered on the stake point and 60 centimeters in depth. Sticks cut to 40 centimeters and 60 centimeters can be used to gauge dimensions while digging and ensuring uniformity.
- Set date for completion of digging the fence post holes (Photograph 14).

Photograph 14
Digging the fence post holes.
Panmedawachchiya, Trincomalee District, Sri Lanka.

Interim of Steps 8 and 9

- Prepare materials list based on data from step 8
- Order materials

Step 9

Objective: Assess adequacy of prepared fence post holes

Participants: Fence committee

Timeline: Upon completion of fence post holes

Activities:

- Inspect prepared fence post holes and point out any shortfalls. Each hole should conform to the dimensions given, especially depth. They should be aligned along the demarcated fence line.
- If any corrections need to be done, set a date for completion.
- If there are no shortfalls, set a date for fence construction, and inform how many helpers will be required per day.
- Inform of requirements for storing fence material.
- If energizer hut is to be constructed by the community, explain construction and set a date for completion (see section 3.10). See Photograph 15.

Photograph 15

Only an expert should connect the energizer.

Tammannawa, Hambantota District, Sri Lanka.

Interim of Steps 9 and 10

Deliver and store fence material.

Step 10

Objective: Install fence (Photographs 16–22)

Participants: Fence committee, adequate number of helpers

Timeline: Upon completion of energizer hut, fence post holes, and delivery of fence material

Photograph 16
Community at work, constructing a village fence.
Tammannawa, Hambantota District, Sri Lanka.

Activities:

- Start with the earth system (refer to energizer manual from manufacturer for proper specifications) and installation of solar panel, controller, battery, and energizer so the completed segments of fence can be immediately energized. Otherwise, sections could be damaged by elephants.
- Follow manual for installation of energizer and connecting it to the earth system and fence.
- Installation of the fence (Photographs 16–22) should be done in segments.
- First the posts are installed and if necessary concreted in place (Photographs 17–18).

Photograph 17

Unloading the fence posts along the fence line.

Panmedawachchiya, Trincomalee District, Sri Lanka

Photograph 18

Concreting a fence post in place.

Mudaliyarkulam, Trincomalee District, Sri Lanka.

- Where the fence changes direction, corner posts and jack posts need to be installed (Photograph 3, see *page 17*).
- At each gate the flanking posts need to be supported by jack posts (Photograph 19).
- Once the posts are firmly installed, insulators are fixed to the posts.
- The wire is let out using a wire dispenser to prevent damage to the galvanized coating (see Photograph 20).

Photograph 19

Gate with gate-spring unit in place. Note flanking posts supported by jack posts.

Tammannawa, Hambantota District, Sri Lanka.

Photograph 20

Dispensing wire with a wire dispenser.

Veppankulam, Trincomalee District, Sri Lanka.

- The wire is strung by pulling the wire through the reel insulators.
- Wire ends should be connected with joint clamps.
- Where the fence changes direction (at corner posts) and at each gate, the wire is cut and connected across strain insulators.
- A tension spring can be installed next to the strain insulators, for each span of the fence, one for each wire.
- Wire tighteners are installed at the midpoint of each segment, and the wire is tightened so it does not sag markedly (Photograph 21). The wire should not be tensioned to a high level until it is perfectly straight and taut because it strains the posts, which may crack (if concrete posts are used).

Photograph 21
Adjusting wire tension with the wire tightener handle.
Bundala, Hambantota District, Sri Lanka.

- At each gate a lead-out cable is placed in a PVC pipe and laid underground bridging the gate opening and connecting the wires on the gate posts on either side.
- If an earth wire is used, it needs to be routed underground across gates through lead-out cables.
- PVC elbows should be fixed to the ends of the PVC pipes so the opening points down to prevent rainwater getting in.
- The lead-out cable should be connected to the fence wire with joint clamps.

- The gate is closed through a coiled wire with an insulated handle and a hook at one end clipped onto the wire.
- The permanently attached end of the coil is not connected to any energized wire and is attached to a gate post through a strain insulator.
- Only when the hook end is clipped to the energized wire at the disconnectable end is the coil energized.
- If an earth wire is installed, earth pegs should be placed at intervals of about 500 meters along the fence line and the earth wire connected to them with wire clamps and clips.
- Once the fence is installed and energized, check fence voltage with a fence meter compatible with the energizer used; correct any current leakages.
- Install the fence post guards (Photograph 22).

Photograph 22
Installing GI mesh fence post guards.
Mudaliyarkulam, Trincomalee District, Sri Lanka.

- Install danger signs in community areas, at gates across public roads, and any other key locations.
- Install fence indicator lights (if used).

Step 11

Objective: Declaration of fence opening

Participants: Entire community, authorities and officials, implementing agency representatives

Timeline: Two to three months after fence construction is completed and fence is functioning well

Activities:

- A formal fence opening fosters community value and ownership of the fence.
- A memorandum of understanding (MOU) should be signed at the fence opening with the fence committee signing on behalf of the village and officials and implementing agency representatives.
- The MOU should include (a) maintenance schedule; (b) conditions of handing over the fence (mainly responsibilities for maintaining the fence and for the fence material); (c) penalties for noncompliance and conditions for fence removal; (d) a list of householders with signatures attesting everybody's acceptance of the MOU.

Step 12

Objective: Fence monitoring (see Annex 3B for form)

Participants: Implementing or monitoring agency official and assigned farmer

Timeline: Weekly during the first year (see section 3.7)

Data Sheets

Questionnaire for Surveying Village Residents (Before Fence)	**Annex 3A**
Village Fence Monitoring	**Annex 3B**
Questionnaire for Assessing Fence Effectiveness (After Fence)	**Annex 3C**

Annexes - Data Sheets

Annex 3A

Questionnaire for Surveying Village Residents (Before Fence)

Interviewer: ..... Date: .....

Name: .....

Village: .....

GPS: N.....º ..... E.....º .....

1. Present occupation:

- ☐ Farmer
- ☐ Government employee
- ☐ Businessman
- ☐ Housewife
- ☐ Laborer
- ☐ .....

2. What is your monthly household income? *

- ☐ <2,000 LKR
- ☐ 5,001–10,000 LKR
- ☐ 2,000–5,000 LKR
- ☐ >10,000 LKR

* Adjust to currency and amounts suitable in your fence area

3. What crops are cultivated in your home garden currently?

Name	Extent (Area or Number of trees)
……	……
……	……
……	……
……	……
……	……

4. What was the value of crops you obtained from your home garden in the last year?

……

5. Have you suffered any damage (crop loss/property damage/injury) from wild animals within the past year?

☐ yes ☐ no

6. *(if 'yes' to Q5 above)* Which three species caused most damage? Please prioritize.

☐ pigs	……	☐ rats	……
☐ monkeys	……	☐ hares	……
☐ deer	……	☐ birds	……
☐ elephants	……	☐	……
☐ porcupines	……	☐	……

7. Are there elephants in this area? ☐ yes ☐ no ☐ not sure

8. How do you feel about elephants being present in this area?

- ☐ good
- ☐ moderate problem
- ☐ no opinion
- ☐ major problem
- ☐ minor problem

9. If a problem, why? Give up to three answers and prioritize.

- ☐ crop damage .....
- ☐ human deaths .....
- ☐ property damage .....
- ☐ loss of safety .....
- ☐ human injuries .....
- ☐ .....

10. What should be done about the elephants in this area?

- ☐ nothing
- ☐ shoot problem elephants
- ☐ translocate problem elephants
- ☐ shoot all elephants
- ☐ translocate all elephants
- ☐ .....
- ☐ village electric fence

11. Did you have crop loss in your home garden from elephants in the last year? If so, how many times?

☐ no loss ☐ 1 x ☐ 2–5 x ☐ 6–10 x ☐ > 10 x

12. If you had crop loss, what is the total value of crops damaged? .....

13. Have you had property damage from elephants in the last year?

☐ no ☐ 1 x ☐ 2–5 x

14. If yes, what is the total value of property damaged? .....

15. Do you think a village electric fence can prevent elephants coming into the village?

☐ no ☐ yes

16. Are you willing to contribute to the cost of an electric fence protecting the village?

☐ no ☐ yes

17. Are you willing to contribute labor for constructing an electric fence protecting the village?

☐ no ☐ yes

Annex 3B

Village Fence Monitoring

Fence Name: .....

Team: ..... Date: .....

Time Start: ..... Time End: .....

Voltage at Post # **

1.....	100	200 .....
300	400	500 .....
600	700	800 .....
900	1,000	1,100.....

** Decide on Post # based on the number of posts used in your fence, to check the voltage of your fence about 10 times.

Note: Record the signs of elephant presence next to the fence (dung/footprints) in the 'comments' column of the table.

			Post at angle		Post fell						Live wire touching				Comments
Incident No.	Post start	Post end	In	Out	In	Out	Object fell on fence	Wire loose	Wire broken	Plants touch wire	Ground	Post	Water	Earth wire	
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															

Annex 3C

Questionnaire for Assessing Fence Effectiveness (After Fence)

Interviewer: ..... Date: .....

Name: .....

Village: .....

GPS: N.....º ..... E....º .....

1. Present occupation:

- ☐ Farmer
- ☐ Government employee
- ☐ Businessman
- ☐ Housewife
- ☐ Labourer
- ☐ .....

2. What is your monthly household income? *

- ☐ <2,000 LKR
- ☐ 5,001–10,000 LKR
- ☐ 2,000–5000 LKR
- ☐ >10,000 LKR

* Adjust to currency and amounts suitable in your fence area

3. What crops are cultivated in your home garden currently?

Name	Extent (Area or Number of trees)
……	……
……	……
……	……
……	……
……	……

4. What was the value of crops you obtained from your home garden in the last year?

……

5. Have you suffered any damage (crop loss/property damage/injury) from wild animals within the past year?

☐ yes ☐ no

6. *(if 'yes' to Q5 above)* Which three species caused most damage? Please prioritize.

☐ pigs	……	☐ rats	……
☐ monkeys	……	☐ hares	……
☐ deer	……	☐ birds	……
☐ elephants	……	☐	……
☐ porcupines	……	☐	……

7. How do you feel about elephants being present in this area?

☐ good ☐ moderate problem

☐ no opinion ☐ major problem

☐ minor problem

8. If a problem, why? Give up to three answers and prioritize.

☐ crop damage ..... ☐ human deaths .....

☐ property damage ..... ☐ loss of safety .....

☐ human injuries ..... ☐ .....

9. What should be done about the elephants in this area?

☐ nothing ☐ shoot problem elephants

☐ translocate problem elephants ☐ shoot all elephants

☐ translocate all elephants ☐ .....

10. Did you have crop loss in your home garden from elephants in the last year? If so, how many times?

☐ no loss ☐ 1 x ☐ 2–5 x ☐ 6–10 x ☐ > 10 x

11. If you had crop loss, what is the total value of crops damaged? .....

12. Have you had property damage from elephants in the last year?

☐ no ☐ 1 x ☐ 2–5 x

13. If you had property damage, what is the total value of property damaged? .....

14. Do you think the village electric fence is a success?

☐ no ☐ yes

15. Are you willing to continue contributing to the fence maintenance fund?

☐ no ☐ yes

16. Are you willing to continue contributing labor for maintaining the electric fence?

☐ no ☐ yes

4. Community-Based Seasonal Agriculture Electric Fences

4.1. Seasonal Fences

Usually electric fences against elephant depredation—such as enclosure or exclosure around settlements—are permanent. However, most agricultural activities are seasonal. Many crops last only three to four months, and in many parts of the world where elephant depredation is an issue such crops are cultivated only during one season annually. Crops entirely dependent on rain may not be cultivated at all in years with insufficient rainfall.

Construction of permanent electric fences around such seasonal agricultural fields is not advisable because during part of the year there is nothing that needs to be protected from elephants. Farmers will not spend time maintaining a permanent electric fence around an agricultural field that is not cultivated. Fences that are not maintained become dysfunctional quickly and elephants will learn to break fences. Therefore, the best option to protect seasonal agriculture from elephants is a seasonal electric fence (Photograph 23). Seasonal electric fences are simplified electric fences that can be deployed comparatively quickly. After harvesting, they are removed and stored until the next cultivation season.

Setting up a seasonal electric fence does not mean that crop guarding can be dispensed with. While an electric fence on the boundary of a cultivated field will prevent most elephant incursions, some elephants may try to challenge and break an electric fence to raid. Also, an electric fence will not prevent raiding by other animals. Therefore, continuation of crop guarding is a must, but the intensity of guarding, for example the number of watch huts and the number of people guarding the fields at any time, etc. can be reduced significantly with the deployment of a seasonal agriculture fence. The deployment of a simple early warning system (See Section 2.3.4) combined with guarding is most effective.

Photograph 23
Paddy field seasonal fence.
Keligama, Hambantota District, Sri Lanka.

4.2. Fence Breaking by Elephants

Since the fence posts of a seasonal agriculture fence are also electrified, elephants cannot easily damage the posts. However, elephants may still break seasonal fences by dragging or toppling trees or branches on to the fence, which can be minimized by removing such vegetation from the fence vicinity. (See also section 2.3.)

4.3. Selecting Agricultural Tracts for Community-Based Fences

Community-based electric fencing is not a solution to all HEC problems. However, given that the main cause of HEC is crop raiding by elephants, it can be effective in many HEC situations. A few criteria are important in determining whether a particular tract of agriculture is suitable for implementing a community-based seasonal electric fencing program.

4.3.1 Community Considerations

- The crops cultivated should be seasonal and not perennial.
- Since the effectiveness of a community-based electric fence is largely dependent on the community, an assessment should be made whether the fence is necessary (Annex 4A for assessment form).
- Indicators are extent, frequency, and seasonality of damages caused by elephants and the economic loss incurred. Lost opportunity costs, and psychosocial impacts are additional indicators. As much as actual damage, whether the farmers perceive raiding by elephants to be a major problem is also important.
- After learning about community-based electric fencing, the farmer community should be keen to embrace it to help themselves overcome HEC and be willing to accept the conditions of providing a fence.
- Each group who has a common identity, such as cultivating a single tract or belonging to one farmer society, should have an independent fence or fence segment.

4.3.2 Geographic Considerations

An exclosure fence is the most appropriate design for a community-based seasonal agriculture electric fence. Therefore, an assessment needs to be made if it is possible. A community-based seasonal agriculture electric fence should (a) enclose land that is only cultivated seasonally; (b) be at the boundary of natural habitat and the currently used field; and (c) not enclose any natural habitat patches within the fence.

4.4. Fence Location

The cardinal principle of an electric fence is that there can be elephants only on one side of it. One main requirement is the absence of elephant habitat on the other side of the fence. Elephant habitat is any sizable area of natural habitat. If there is elephant habitat on both sides of a fence, it is likely to have been previously contiguous elephant habitat. Elephants will break such fences to use familiar areas that were previously part of their home range. If there are elephants on both sides of a fence, it is a failure. Failed electric fences should be removed: they serve no purpose and their persistence encourages elephants to learn to break them (Photographs 4a and 4b), making electric fencing obsolete over a large area.

If there is natural habitat that provides cover to elephants inside an exclosure fence, an elephant coming up to the fence will not be noticed by people. In contrast, if the entire length of the fence can be seen from within the area protected by the fence, an elephant approaching and trying to break the fence is likely to be seen and chased away. Similarly, an elephant approaching a fence with natural habitat adjacent to and inside the fence will not see people and is free to spend a long time figuring out how to break it, because it does not feel exposed or fear detection. Regardless of the design, such fences are likely to be broken by elephants. Therefore, it is very important that lands enclosed within a community-based fence do not have natural vegetation that provides cover for elephants. A simple way to explain it to communities is to say that the fence should be visible when a flashlight is shined from within the area protected by the fence.

One of the main reasons community-based electric fences tend to be less challenged and broken by elephants than fences erected on boundaries of protected areas is the regular presence of people next to the fence. Therefore, in designing a community-based seasonal fence, areas not cultivated that particular season have to be excluded.

When the idea of a seasonal agriculture electric fence is proposed, farmers may desire to enclose a large area: either all land owned by them or additional land they want to acquire. However, enclosing land not currently in use within an exclosure fence decreases its effectiveness. Therefore, it is important to make it clear to the farmer community that a seasonal agriculture electric fence is strictly for protection of their crops from elephants and should never be used as a boundary marker. Since a seasonal fence is deployed only during the cultivation period, it should not have boundary implications for landownership. However, if there are such concerns, the matter needs to be sorted out with the appropriate stakeholders. Locating the fence at the boundary of the field that is currently cultivated is greatly facilitated by requiring individual contribution to fence cost to be in proportion to ownership of land protected by the fence (see section 3.5); people usually do not want to pay for currently unused land.

In summary, community-based seasonal agriculture electric fences are strictly for protecting seasonal cultivations. A fence is effective only if it is close to what it is meant to protect. Therefore, community-based seasonal electric fences should be erected only on the ecological boundary for elephants, which is the perimeter of the field being cultivated (Fig. 3). If only a part of the tract is cultivated in a particular season, only the cultivated section should be fenced for that season (Fig. 3).

Figure 3

Plan of seasonal paddy field electric fence using GPS positions and Google Earth, Badalgama, Kurunegala District, Sri Lanka.

The solid yellow line shows the fence line when the entire tract is cultivated.

The fence line on top would be changed to the dotted line if only the lower part of the tract is cultivated next season.

4.5. Fence Management

The success of an electric fence is largely dependent on maintenance, which is the primary focus of fence management. Electric fence maintenance is simple: the main actions are preventing any plants from germinating under the fence growing up to a meter and touching the wires, lopping off any branches that may touch the fence, and correcting any faults or damages.

Clearing vegetation and inspection of the fence for any breakages should be done periodically. The frequency of inspection (see section 4.6.3) should be determined based on the rate of growth of vegetation causing current leakage and how often fence faults or damages occur. The more frequently a fence is inspected, the more likely that it will function without any issues. Inspection and maintenance are simple for someone cultivating the land adjacent to a fence. For a person cultivating a field by preparing soil, planting, tending and harvesting, maintaining a few meters of fence takes little effort or time. For an employee of an external agency to come from outside and maintain a fence that is protecting a field—while the farmers working next to the fence and are protected by it do nothing—makes little sense. Fences managed by external agencies are likely to be damaged by people for trivial gain or ease, such as cutting wires or not replacing a gate wire when crossing a fence.

Fence management by outside agencies is likely to fail for many reasons, and it dissuades development of a sense of fence ownership by those protected by the fence. In contrast, community management of fences is easy, simple, of little cost, sustainable, and fosters a sense of ownership. Since an effective community-based fence directly benefits the community, it is in the community's best interest to manage it well. Similarly, mismanagement resulting in fence failure directly impacts the community, and they must bear the blame for it.

4.6. Community Organization

If a farmer organization exists for the tract of cultivation, it can be co-opted to do the fence management. If not, a fence committee needs to be set up, whose main task is managing the fence.

4.6.1 Fence Committee Members

The fence committee should have a number of office bearers such as chairman, secretary, and treasurer, and a number of members, depending on the number of farmers. All should be elected from among the farmers to be protected by the fence.

4.6.2 Fence Committee Responsibilities

The tasks include coordinating the processes of establishing the fence, fence maintenance, fence removal and storage, collecting funds, setting up and maintaining a fence maintenance fund, and holding monthly or seasonal meetings and annual elections. The committee should draw up a constitution detailing the responsibilities and processes. The committee is responsible for informing the rest of the farmers about the work required for each step in fence establishment, removal, and storage, and assigning individuals for the tasks.

4.6.3 Fence Maintenance

The fence committee should determine the maintenance procedure and schedule. Farmer communities have successfully adopted mechanisms for fence maintenance, such as (a) daily fence inspection and maintenance by assigned farmers based on a roster: (b) communal maintenance in which a regular date (such as the first and 15th of each month) is set for fence maintenance: (c) allocating responsibility for maintaining segments of fence to individual farmers; and (d) collecting funds from the farmer community and employing personnel to maintain the fence. Proper maintenance is facilitated by an effective penalty, such as a fine levied by the fence committee for nonparticipation or not completing allotted tasks.

4.7. Community Financial Contribution

The higher the monetary investment by the community, the greater its sense of ownership and the likelihood of good maintenance, effectiveness, and long-term sustainability of the fence. Monetary investment by the community consists of contribution to the fence cost and maintenance.

4.7.1 Contribution to Fence Cost

The contribution to fence cost is a one-time event. The amounts to be contributed by individual farmers are determined based on the extent of their land protected by the fence. A standard amount per unit of land is determined in consultation with the farmers, based on their ability

to pay. If the farmers are unable to assess the amount of land they own, GPS mapping of individually owned plots within the proposed fence line, inputting the GPS positions to Google Earth, drawing a polygon, and assessing the area could be done. A listing of individuals, extent of land, and contribution amount is drawn up and displayed publicly.

4.7.2 Contribution to Fence Maintenance

The contributions are periodically collected, usually once every cultivation season. A flat rate is levied per farmer, or it can be pro-rated in relation to amount of land owned. The amount to be collected is determined in consultation with the farmers, based on their ability to pay. The amount collected should be sufficient to develop a fund that will be able to cover repairs to the fence and fence components such as fence posts in the short term, battery in the midterm (two years on), and energizer, solar panel, and wires in the long term (five years on). When the handling of community generated funds by the implementing agency is not possible because of internal constraints (as in government agencies), the fence committee should collect the same amount of funds as for contribution to fence cost and use it to establish the fence maintenance fund to which would be added the fee levied seasonally.

A transparent process of managing the finances is important, with maintenance of books, guidelines for fund withdrawal, and regular presentation of accounts to the community. If an existing farmer organization is co-opted for fence management, it is advisable to set up a separate bank account for the fence. If communities do not have the capacity to maintain accounts, capacity development needs to be part of community engagement by the implementing agency.

4.8. Community Labor Contribution

The farmer community should provide the entire labor required for constructing and maintaining the fence. Farmers should not be paid by the implementing agency for their labor, because it strongly advocates fence ownership by the agency and not the community.

A number of activities in fence construction—such as clearing of land enclosed by the fence, clearing and preparing the fence line, digging fence post holes, construction of energizer hut, planting fence posts, and stringing the wire—require labor (as do fence inspection, clearing, and repairs for fence maintenance). Farmers who cannot participate could provide personally hired labor to replace them. Some activities, such as clearing the fence line, could be done manually or by hiring a bulldozer or excavator. If the farmers opt for such activities, they should collect funds for it and bear the extra cost.

In allocating labor or collecting funds for maintenance, the farmer community should decide whether to do it in proportion to ownership of land included within the fence or to divide equally among farmers. Coordination of these activities and their supervision is the responsibility of the fence committee.

4.9. Fence Monitoring

After completion, the fence should be monitored weekly for the entire cultivation period. An officer from an external agency (usually the implementation agency) and an assigned

farmer (the fence committee assigns a farmer based on a roster) monitor the fence together. The entire fence line is walked, and the voltage checked at 50-meter intervals using a voltmeter. Problems such as vegetation touching the wires, wire touching the ground, loose wires, or posts at an angle are noted in respect to the numbered posts (see annex 4B for fence monitoring form). At the same time the assigned farmer is shown the defects. The farmer informs the fence committee, and the deficiencies need to be corrected immediately.

4.10 Implementation Agencies

Community-based electric fencing is entirely for protecting communities from elephant depredation. Therefore, from a philosophical point of view, whether conservation agencies should bear the responsibility for implementing community-based fencing programs is questionable.

4.10.1 Human Resources

To be effective at HEC mitigation over a landscape scale, community-based fences have to be small and numerous. Each fence requires community engagement for an extended period of time for its deployment and needs to be monitored regularly once completed to ensure success.

Conservation agencies rarely have the human resources to contend with the numbers of community-based electric fences required to make a real impact on HEC mitigation at a landscape scale. However, agencies whose main responsibility is people's welfare and development are numerous. These agencies tend to have extensive networks based among the people. They are likely to have a much better relationship with communities than conservation agencies and have authority over the people. They are far better positioned than conservation agencies to implement community-based fencing programs. If agencies whose main focus is people's welfare and development implement community-based fencing, the scale of human resources is not an issue.

4.10.2 Funds

To be effective at a landscape scale, community-based electric fencing requires a much greater investment in funds than an approach of limiting elephants to protected areas by electric fences. In most cases, conservation agencies do not and will not have access to the scale of funds required for an effective community-based fencing program at a landscape scale. In contrast, agencies responsible for people's welfare and development have access to greater funds. If such agencies implement community-based fencing programs, funding is not an issue.

The appropriate agencies for implementing community-based electric fencing are not conservation agencies, but administrative and development agencies. However, because traditionally HEC mitigation has been the preserve of conservation agencies, it may be difficult to effect such a change immediately, and conservation agencies may need to implement a few community-based fences as examples.

4.11. Personnel Implementing Seasonal Agriculture Electric Fencing Programs

To ensure success of a community fencing program, it is best to identify a group of people who will carry out such programs

and train them. Personnel implementing a community-based fencing program should have the following:

- A clear idea of the objectives of community-based fences and the rationale behind it.
- Ability to work with communities including conducting awareness programs, community organization and motivation, and settling disputes.
- Expertise in use of GPS units and Google Earth.
- Knowledge of the components of an electric fence and their function.
- Ability to estimate fence material quantities and their purchase.
- Experience in installing seasonal electric fences.
- Experience in monitoring and maintaining electric fences.

While this guidebook provides direction, personnel involved in implementing a community-based fencing program need to have practical training in setting up electric fences.

4.12. Selection of Fence Materials and Equipment

Always use good quality components. Cheap components are likely to fail, last a much shorter length of time, and therefore need frequent replacement (hence, in the long term they will cost more). Remember that it is better to construct one expensive fence that works properly than two cheap ones that do not!

A brief introduction to the main components and their use in the context of seasonal agriculture electric fences against elephant depredation is provided here. For detailed accounts of each component and its installation, please refer to manuals available from electric fence material suppliers.

4.12.1 Fence Posts

Medium thickness galvanized iron (GI) pipes are used for the fence posts. For corner and gate posts, 32-millimeter diameter pipes and for middle posts 25-millimeter pipes are used, respectively. The live wires are not isolated from the posts because the posts are also energized. Metal rings (thick steel washers can be used) are welded to the fence post to carry the wire (Photograph 24). Care should be exercised to make sure the top and bottom rings are in line when welding.

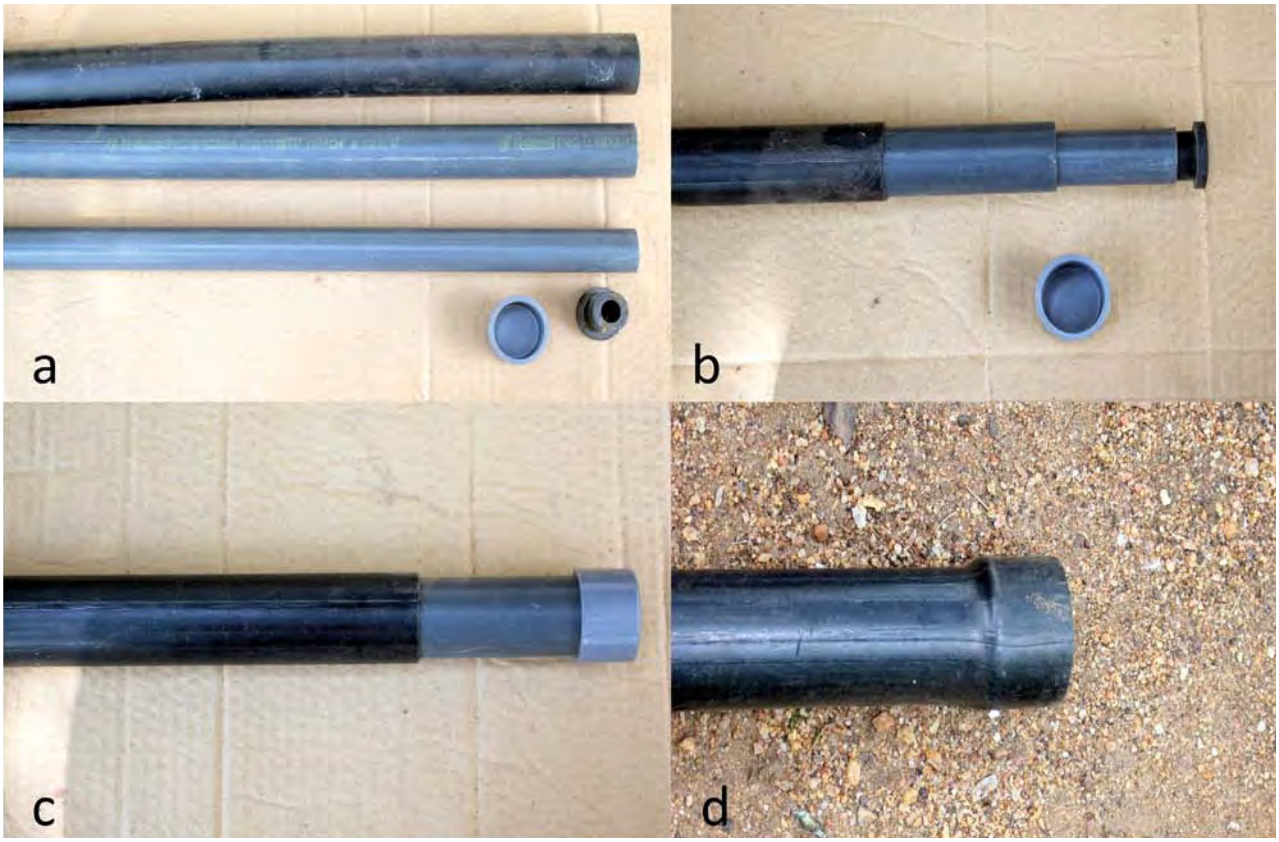
Fence posts should be 250 centimeters tall and buried 60 centimeters in the ground, making their standing height once installed, 190 centimeters. The height of the fence post (and wires) may have to be increased if elephants manage to step over the fence at these measurements.

Photograph 24

Rings welded onto the fence posts to carry the wire.

4.12.2 Fence Post Ground Insulator

Because the post is energized, current leaking to the ground is prevented by inserting the bottom of the post in a sealed medium density polyethylene (MDPE)/PVC combination sleeve that is sealed at one end with an end cap. See Photograph 25a–25d. Using a two- or three-layer sleeve with the outer one of MDPE (or alkathene) helps prevent current leaks. The sleeve needs to be 75 centimeters long so that 15 centimeters of it projects above the ground. Appropriate sleeves should be used for each size of post so that the sleeves and post snugly fit inside each other. A piece of rubber about 2.5 centimeters (a vehicle bush that fits the innermost sleeve can be used) is inserted into the inner sleeve so that it cushions the bottom of the GI pipe and prevents it from cracking the end cap (Photograph 4b). The posts should be gently inserted into the sleeve to ensure the end cap is not damaged.



Photograph 25
Preparing a three-layer fence post ground insulator for a 20-millimeter diameter fence post.

25a Material: outer MDPE sleeve; mid and inner PVC sleeves; PVC end cap that fits the mid PVC sleeve; rubber bush that fits inner PVC sleeve.

25b and **25c** Assembling the unit, only the end cap is glued on.

25d Fully assembled insulator.

4.12.3 Post Guards

Elephants may learn to kick the fence post ground insulator because it is not energized and projects about 15 centimeters from the ground. Making the sleeve project above the ground for a shorter length is not advisable because maintenance is more difficult: even very short vegetation around the post will touch the post and cause current leakage. Also, farmers tend not to be exact in making the fence post holes and installation of ground insulators. If the sleeve projects only a few centimeters above the ground level, the posts may be earthed, especially when it rains. Instead, a simple guard can be fashioned with a piece of nontensile GI wire so that the elephant cannot kick the sleeve (Photograph 26). A piece of GI mesh 30x30 centimeters can be similarly used by inserting the post through its center.

Photograph 26
Post guard fashioned out of a piece of nontensile GI wire.

4.12.4 Wire

Heavy galvanized high tensile steel wire 1.6 millimeters thick is used for seasonal fences. Two strands of wire should be used. The top wire should be close to the top of the post, and the bottom wire should be 90 centimeters from the top wire. Since seasonal fences are of comparatively short length and border cultivated areas, two live wires are used and no earth wire is needed.

4.12.5 Lead-Out Cable

Insulated high tensile heavy galvanized steel wire, equal to or greater in diameter than the fence wire, is used to (a) route the current underground for gates, (b) connect the earth terminal to the earth system, and (c) if necessary, to conduct current to the fence from the energizer. Insulated household wire or cables made of other material, such as copper, should not be used for this purpose because using different metals in the electric circuit leads to electrolysis and rapid corrosion of some components.

4.12.6 Gate Springs

Gate spring and handle units can be purchased from fence material suppliers or fabricated using the fence wire and a piece of PVC tubing.

4.12.7 Joint Clamps

Use joint clamps to splice wires rather than tying them because it will give a better connection and prevent having to cut off sections when the wire is reused.

4.12.8 Energizer

Most locations where a seasonal agriculture fence will be used may not have mains grid electricity nearby. However, an energizer that works off a 12-volt battery current can be used instead. Where mains current is available, and a mains grid powered energizer is used, make absolutely certain that the farmers and all involved understand that the mains current should never be connected to the fence directly and it should only be used to power the energizer. Connecting mains current to the fence is illegal and creates a lethal fence that will kill persons or animals touching it. If there is any doubt about the farmers' reliability do not install a mains powered energizer.

An energizer with an output joule rating above 3.5 joules (stored joule rating above 5 joules) should be used. When connected to the fence it should maintain a voltage above 6,000 volts. An energizer with an integrated alarm is preferable. Such units sound a loud alarm when a voltage drop occurs as when the live wire is broken and grounded or the battery current drops. More advanced models can also sound an alarm when an animal contacts the wire.

4.12.9 Earth System

A good earth system is a must for the functioning of an electric fence. It is usually located close to the energizer, ideally where the ground retains moisture throughout the year. The earth system can be installed permanently. About five galvanized steel rods are driven into the soil to 1.5 meters deep, spaced 3 meters apart, and connected to each other in series and to the earth terminal of the energizer with an insulated cable. The cable should be connected to the rods with clamps (taking the insulation off the cable at the point of contact). Refer to the manuals from parts suppliers for proper installation of the earth system. Earth rods used for the earth system of houses are usually copper-plated and should not be used because different metals in the electric circuit will lead to electrolysis and rapid corrosion of some components.

4.12.10 Energizer Cabin

A small enclosure that can be removed and stored easily can be fabricated from sheet metal (Photographs 8 and 27). It should have sufficient room for the energizer, controller, and battery. The energizer should be close to the fence and to the earth system. If the energizer has to be some distance away from the fence, the electricity should be conducted to the fence along a lead-out cable. An energizer should not be housed inside a hut or other living quarters.

Photograph 27

Energizer cabin and solar panel. Sri Lanka

4.12.11 Battery, Controller, and Solar Panel

If special batteries for electric fences are available, they would be ideal. However, an automotive 12-volt lead acid battery is adequate. It is preferable to use a sealed battery so that regular battery maintenance is not required and its lifetime is longer. If a nonsealed battery is used, instruct the fence committee on battery maintenance and include it in the maintenance schedule. The required battery size (amperage) will depend on the model of the energizer. The controller and solar panel will depend on the battery.

The solar panel needs to be cleaned at intervals determined by environmental conditions such as dust deposition on the panel. Follow the manuals from the supplier or get expert help for aligning the solar panel to the sun and installation of the controller and battery. Once the battery is stored after use, recharging at intervals may be required. Check with the battery supplier, and instruct the fence committee accordingly and include it in the maintenance schedule.

4.12.12 Lightning Diverters

Connect the fence to a lightning diverter so that any lightning striking the fence is conducted to the earth system and does not destroy the costly energizer.

4.12.13 Warning Signs

Sign plates with a warning that this is a high-voltage electric fence should be installed at fence sections traversing community areas.

4.12.14 Fence Indicator Light

Fence indicator lights that illuminate when the fence is charged can be installed at intervals along the fence. While not essential, they will alert people along the fence when the fence is activated.

4.12.15 Implements

- **Wire dispenser.** Used when constructing the fence.
- **Wire cutting pliers.** Special pliers are available from electric fence material suppliers that make handling and cutting of the wire easy. High tensile steel wires are difficult to manipulate using household pliers.
- **Voltmeter.** A voltmeter compatible with the energizer is required to check voltage, detect leaks, and monitor the electric fence. The fence committee and the monitoring agency should each have one. It is preferable to get the voltmeter from the same supplier as the energizer to ensure compatibility.

4.13. Required Materials

Table 2: Required Materials for Seasonal Fence Building

#	DESCRIPTION	QUANTITY
	Material used once in a fence	
1	Energizer	1
2	Lightning diverter	1
3	Alarm with siren and strobe light (compatible with energizer)	1
4	Earth rod (length: 2 m / hot dip galvanized)	7
5	Earth rod wire clamp	7
6	Solar Panel (60 W) and mounting kit set	1
7	Solar charge controller (20 A)	1
8	Lead acid battery (90 A)	1
9	Energizer cabin	1
10	PVC pipe (diameter: 20 mm)	10 m
11	PVC bend socket (diameter: 20 mm)	15
12	Insulated lead-out cable (diameter: 2.5 mm)	60 m

#	DESCRIPTION	QUANTITY
Material for 1 km of fence line (multiply by fence length in km)		
1	High tensile heavy galvanized steel wire (diameter: 1.6 mm)	2,200 m
2	GI fence middle posts (diameter: 25 mm; length: 250 cm)	66
3	Fence post ground insulators for 20 mm diameter posts	66
4	Warning sign boards	3
Add for each span		
1	GI fence corner posts (diameter: 32 mm; length: 250 cm)	1+ no. of spans
2	Wooden ground pegs (length: 1 m)	2/corner post
3	Strain (bull-nose) insulators	2/corner post
4	Fence post ground insulators for 32 mm diameter posts	1/corner post

Note: Fence post ground insulators need to be fabricated and metal rings need to be welded onto the fence posts (these are not included in table). The length of 20-millimeter PVC pipe and lead-out cable will change depending on distance of energizer to fence. The calculation is based on two guy wires per corner post, but some may require only one.

4.14. Cost of Fence Materials

In general, the per kilometer cost for fence material for a seasonal electric fence will be around US$1,000 to US$2,500 (as estimated based on prices in Sri Lanka in 2019).

- Of this, fence posts will be about 20 percent to 40 percent of the total.
- The cost of wire (two strands) and lead-out cable will be around 15 percent of the total.
- Energizer, solar panel, and controller will cost around 25 percent to 45 percent of the total.
- Other components will make up the balance.

The cost of components needed only once per fence, such as the energizer and battery, make up a relatively small percentage of the total cost, especially for longer (5 kilometer or more) fences. Therefore, obtaining low-cost units that are likely to be of low quality for these components does not make much difference to the total cost but will have a major impact on fence function.

4.15. Assessing Fence Effectiveness

4.15.1 Monitoring records

The data recorded during the weekly monitoring provide a good indicator of the effectiveness of a fence (Annex 4B). Recording of elephant signs adjacent to the fence shows the presence of elephants that may have entered the cultivation area if not for the fence. If there are any fence breakages by elephants, their increase or decrease with time indicates the long-term viability of the fence.

4.15.2 Surveys

Community surveys before the establishment of a fence and after one or more seasons of cultivations provide a good indicator of the effectiveness of the fence (Annex 4A and 4C). However, results may need to be interpreted based on other environmental variables that may have an impact on raiding of crops by elephants.

A questionnaire can be administered to all the farmers or a random sample depending on the size of the cultivation area protected by the community-based fence. Comparison with fields protected by community-based fences and those that are not in the same area provides another viewpoint. However, because of influence of many other factors on HEC, such comparisons would be useful only with a large number of protected and unprotected fields.

Questionnaire surveys can be used to assess the income gained from cultivation and losses experienced within the fenced area before and after fence installation. Perceptions and attitudes of the farmers toward HEC and its management, elephants, and elephant conservation are also useful indicators of the impacts of the fence. Indicators such as the number of elephant and human deaths are not valid parameters for assessing effectiveness of community-based fences because of the rarity of such events at a relevant scale and the varied (not fence-related) reasons for their causation.

4.16 Guidelines, activities, and protocols

Following is a suggested step-by-step procedure for establishing a community-based seasonal agriculture electric fence. It is meant as an example of the process and may need to be changed according to local requirements and conditions.

Step 1

Objective: Assessing suitability of location

Community considerations:
Questionnaire survey of farmers, discussions with community leaders, and secondary data from relevant agencies can indicate whether cultivation is done seasonally, and if that farmer community experiences significant HEC and is keen to adopt community-based electric fencing for its mitigation (see section 3.1.).

Geographic considerations:
Taking a few GPS positions with a handheld unit and seeing the proposed location on Google Earth provides an assessment of whether a location is likely to fulfill the geographic criteria for a community-based fence (see section 3.1.).

- If both community and geographic criteria appear to be fulfilled, introduce the idea of community-based electric fencing to a few community leaders and assess interest.
- If positive, they should organize a meeting in which specifics are explained to the entire community.

Step 2

Objective: Awareness program

Participants: Entire farmer community

Material: Laptop computer, multimedia projector, screen, presentation on electric fencing

Activities:

- Discuss the problems the farmers have with elephants, how often damages occur, what they are currently doing to prevent raiding and the success of current practices.
- This can be followed by a presentation about electric fencing.

Specifics to be explained:

- Community-based electric fencing can help communities overcome raiding by elephants to a large extent. They can be helped to achieve it, but it is not something that someone else can do for them.
- How an electric fence works (see section 2.1.).
- Differences between enclosure or linear fences and community-based electric fences (see section 2.2.).
- Difference between permanent and seasonal fences (see section 2.3.).
- Approximate cost of electric fencing (see section 3.12.).

- Conditions of providing assistance to construct an electric fence.
    - Introduce the idea of community monetary contribution and role with regard to cost, deployment, maintenance, removal and storage.
    - Fence management (see section 3.3.).
    - Circumstances under which the fence will be discontinued.

After the presentation, the farmer community is given time (one to two weeks) to discuss what has been presented and to make a decision.

Step 3

Objectives: Election of fence committee (if there is no existing farmer society)
Determination of contribution to fence cost
Fence line demarcation with stakes

Participants: Entire farmer community, representatives of relevant authorities (administrative, agricultural and conservation sectors, etc.)

Timeline: Two to four weeks after step 2

Material: Handheld GPS, adequate number of stakes (based on rough estimate from Google Earth analysis

Activities: At the community meeting the following should be addressed:

- Clarifications or concerns of the villagers regarding the program
- Fence committee (see section 3.4.)
    - Description of responsibilities and tasks
    - Composition
    - Election of office bearers
- Financial contribution towards fence cost (see section 3.5.)
    - Rationale for contribution in proportion to land ownership
    - Determine contribution amount per unit (e.g., per acre or ha) of land

Initial fence line demarcation:

- Explain rationale for excluding unused or unoccupied land (see section 3.2.).
- Walk along the proposed fence line with farmers and demarcate the line by planting stakes every 20 meters.
- Take GPS positions every 50 meters and at any change of direction.
- Set a date for finalizing the fence line (give the people one to two weeks to decide the fence line).

Interim of Steps 3 and 4

- Assess proposed fence line by seeing it on Google Earth using the GPS points obtained in step 3.
- Calculate length of fence and area covered.
- Determine any changes needed to the fence line (e.g., excluding natural habitat or unoccupied plots).

Step 4

Objectives: Finalizing the fence line
Decide on individual fence cost contribution
Determination of fund collecting and management procedure

Participants: Entire community

Timeline: One to two weeks after step 3

Activities:

- Project Google Earth image with proposed fence line.
- Discuss any changes that need to be made.
- If agreement is not reached on the fence line, ask community members to inform when agreement can be reached. If there are proposed changes, call an additional meeting to finalize the fence line.
- If agreement is reached on the fence line, determine if the community has knowledge of individual ownership extent of each enclosed plot of cultivation. If not, set date for GPS mapping of individual plots.
- Fund collection: once the fence line is finalized, the fence committee should set up a bank account, prepare the list of farmers, collect the funds (to deposit in a bank account or hand over to implementing agency) (see section 3.5.).

Interim of Steps 4 and 5

- If required, GPS mapping of individual plots, determination of extent of land and finalizing the list of individuals, land extent, and amount to be paid by each household.
- Fence committee collects funds for contribution and deposits in dedicated account or hands over the funds.

Step 5

Objective: Demarcating fence line

Participants: Fence committee, sufficient number of helpers

Timeline: Upon completion of fund collection

Material: Handheld GPS, adequate number of stakes

Activities:

- Map the fence line by walking along edge of cultivation area with a handheld GPS unit.
- Take GPS positions every 50 meters and at any change of direction.
- Note corner posts and gates.
- Mark line by planting stakes every 20 meters and at any change of direction.
- Instruct fence committee on specifications of clearing (3 meters on either side of demarcated line). The strip should be cleared of vegetation and reasonably leveled. Large rocks, termite mounds, and so on should be avoided by the fence line or removed.
- Set date for completion of clearing the fence line.
- Inform about how to store fence material.

Interim of Steps 5 and 6

- Estimate fence material requirements based on data from step 4.
- Place order for fence material.

Usually two live wires are sufficient, but three wires can also be used. Since the fence borders a cultivated area, ground moisture (from watering the crops) along the length should be sufficient for earthing. Therefore, an earth wire is usually not needed.

Step 6

Objective: Inspection of fence line clearing

Participants: Fence committee

Timeline: Upon being informed that the fence line has been cleared

Activities:

- Walk the fence line with the fence committee and inspect if the fence line clearing is adequate.
- If not, instruct it to be completed by set date for proceeding with the fence.

Interim of Steps 6 and 7

- Deliver and store fence material.
- Prepare fence posts and fence post ground insulators.

Step 7

Objective: Installing the fence (photographs 28–34)

Participants: Fence committee and sufficient helpers

Timeline: Upon confirmation of adequate fence line clearing and delivery of fence material

Material: Adequate number of stakes, 150-meter cord marked every 15 meters with knots or tape, wrapping the cord on a reel so that it can be played out is useful (Photograph 12)

Activities:

- Along the fence line, position the marked cord in the middle of the cleared strip so each segment of the fence conforms to a straight line (Photographs 12 and 13 on *page 44*).
- Mark fence post positions by planting stakes at each 15-meter marking and at all points where the fence line changes direction.
- As the positions are marked, fence post holes are dug out by another group by driving the pointed end of a GI pipe, of larger diameter than the post to be planted, into the ground with a heavy mallet (Photograph 28). It is driven in about 30 centimeters, pulled out, the soil plug in the pipe removed, and repeated.

Photograph 28
Making holes for fence post.
Rotawala, Hambantota District, Sri Lanka.

- Install the energizer cabin and mount solar panel, controller, battery, and energizer (Photograph 29).
- Set up the earth system (Photograph 30) and connect it to the energizer.
- Follow manual for installing energizer and connecting to earth system and fence.
- Check the depth of fence post holes, insert posts, and tamp down the earth around it.

Photograph 29

Setting up the energizer cabin.

Orukemgala, Hambantota District, Sri Lanka.

Photograph 30

Setting up the earth system.

Orukemgala, Hambantota District, Sri Lanka.

- At gates and where the fence changes direction, corner posts should be installed and supported by guy wires and wooden stakes, with the guy wire connected to the stake through a strain insulator because the guy wire is energized (Photograph 31).
- String the wire by pulling it through the rings on the posts (Photograph 32).

Photograph 31

Supporting corner post with a guy wire.

Rotawala, Hambantota District, Sri Lanka.

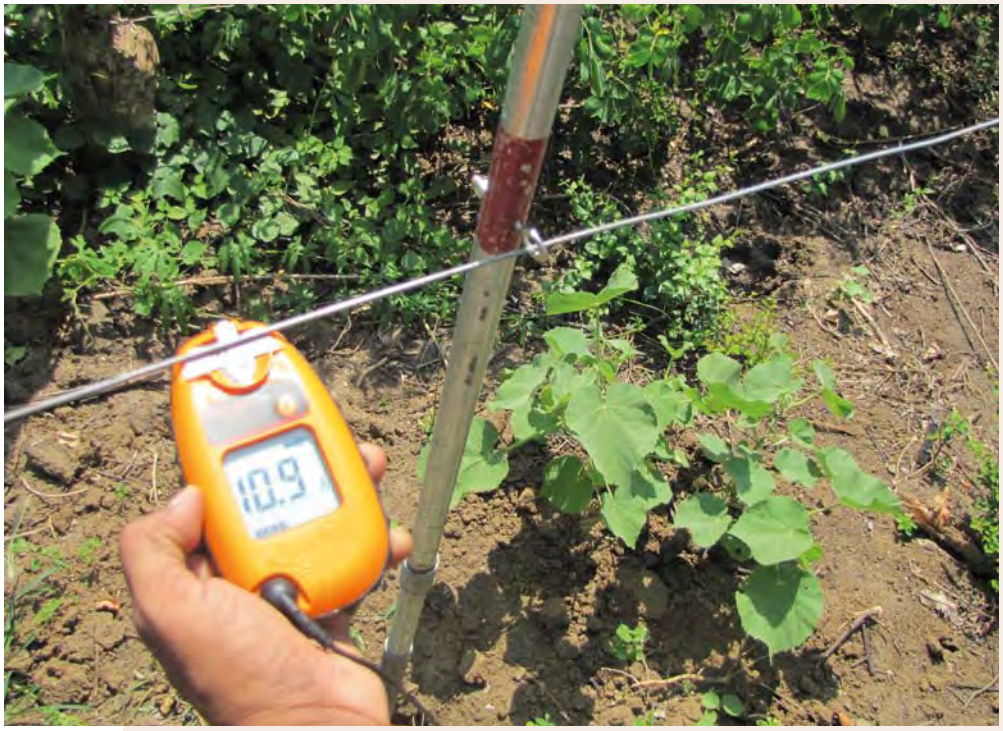
Photograph 32

Pulling the wire.

Veppankulam, Trincomalee District, Sri Lanka.

- The wire is dispensed using a wire dispenser (Photograph 33) to prevent damage to the galvanized coating.
- Once the fence is installed and energized, check fence voltage with a fence meter compatible with the energizer used. Correct any current leakages (Photograph 34).

Photograph 33
Dispensing wire with a wire dispenser.
Veppankulam, Trincomalee District, Sri Lanka.



Photograph 34
Checking the voltage along the fence.

Step 8

Objective: Formal fence opening

Participants: Entire farmer community, relevant authorities, officials, implementing agency representatives

Timeline: Once fence is completed

- Having a formal fence opening fosters community value and ownership of the fence.
- A memorandum of understanding (MOU) should be signed at the fence opening with the fence committee signing on behalf of the farmers and signing by officials and implementing agency representatives.
- The MOU should include (a) maintenance schedule; (b) conditions of handing over the fence (mainly responsibility for maintaining the fence and for the fence material); (c) penalties for noncompliance and conditions for fence removal; and (d) list of farmers with signatures attesting their acceptance of the MOU.

Step 9

Objective: Fence monitoring

Participants: Implementing and monitoring agency official and assigned farmer

Timeline: Weekly during the period the fence is in use (see section 3.7)

Step 10

Objective: Fence removal and storage

Participants: Fence committee and sufficient helpers

Timeline: Upon harvest

- The fence is dismantled in sections and stored (Photographs 35a and 35b). Even if the start of the next cultivation season is one week later, the fence should be removed and reinstalled. This condition should be set out before starting fencing and should be included in the MOU. Failure to follow fence dismantling as a routine will encourage keeping the fence for longer periods between cultivations, particularly where the interim period varies between years due to rainfall etc. Keeping the fence installed in between cultivation periods will also make it likely that elephants will break the fence hence get used to fence breaking, leading to its consequent failure or it may obstruct elephant movement and increase conflict. On the other hand removal of the fence will also provide elephants an opportunity to feed on left-over harvest and free movement even for a short time period.

Photograph 35a

Dismantling fence after harvest.

Palujandura, Hambantota District, Sri Lanka

Photograph 35b

Dismantling fence after harvest.

Palujandura, Hambantota District, Sri Lanka.

- Take care when rewinding the wire so it does not drag on the ground and get abraded, as that will hasten corrosion.
- Take care to prevent damage to post ground insulators when they are removed from the ground. If any damages are observed they should be discarded and new ones installed when the fence is reinstalled.
- If the cultivation area is the same and the next season will be commenced in a short time, the post ground insulators could be left in place, which makes reinstallation much easier. However, they are liable to get damaged from trampling by animals or people. Therefore, if left in place, a cover such as an old tin can be used to enclose and protect them.
- Transport and storage facilities for the material needs to be arranged (Photograph 36).

Photograph 36

Transport of dismantled fence for storage.

Veppankulam, Trincomalee District, Sri Lanka.

Step 11

Objective: Fence redeployment

Participants: Fence committee and sufficient helpers

Timeline: Upon next cultivation

- Dates for fence installation should be determined based on when cultivation will commence.
- The fence post ground insulators should be inspected and replaced if damaged.
- Follow same procedure as for original fence installation.

Data Sheets

Questionnaire for Surveying Farmers (Before Fence)	**Annex 4A**
Agriculture Fence monitoring	**Annex 4B**
Questionnaire for Assessing Fence Effectiveness (After Fence)	**Annex 4C**

Annexes - Data Sheets

Annex 4A

Questionnaire for Surveying Farmers (Before Fence)

Interviewer: ..... Date: .....

Name: .....

Village: .....

GPS: N.....º ..... E.....º .....

1. Present occupation:

- ☐ Farmer
- ☐ Government employee
- ☐ Businessman
- ☐ Housewife
- ☐ Labourer
- ☐ .....

2. What is your monthly household income? *

- ☐ <2,000 LKR
- ☐ 5,001–10,000 LKR
- ☐ 2,000–5000 LKR
- ☐ >10,000 LKR

* Adjust to currency and amounts suitable in your fence area

3. What crops are cultivated in your home garden currently?

Name	Extent (Area or Number of trees)
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

4. What was the value of crops you obtained from your home garden in the last year?

.....

5. Have you suffered any damage (crop loss/property damage/injury) from wild animals within the past year?

☐ yes ☐ no

6. *(if 'yes' to Q5 above)* Which three species caused most damage? Please prioritize.

☐ pigs	.....	☐ rats	.....
☐ monkeys	.....	☐ hares	.....
☐ deer	.....	☐ birds	.....
☐ elephants	.....	☐	.....
☐ porcupines	.....	☐	.....

7. Are there elephants in this area?

☐ yes ☐ no ☐ not sure

8. How do you feel about elephants being present in this area?

☐ good ☐ moderate problem

☐ no opinion ☐ major problem

☐ minor problem

9. If a problem, why? Give up to three answers and prioritize.

☐ crop damage …… ☐ human deaths ……

☐ property damage …… ☐ loss of safety ……

☐ human injuries …… ☐ ……

10. What should be done about the elephants in this area?

☐ nothing ☐ shoot problem elephants

☐ translocate problem elephants ☐ shoot all elephants

☐ translocate all elephants ☐ ……

☐ village electric fence

11. Did you have crop loss in your home garden from elephants in the last year? If so, how many times?

☐ no loss ☐ 1 x ☐ 2–5 x ☐ 6–10 x ☐ > 10 x

12. If you had crop loss, what is the total value of crops damaged? ……

13. Have you had property damage from elephants in the last year?

☐ no ☐ 1 x ☐ 2–5 x

14. If yes, what is the total value of property damaged .....

15. Do you think a village electric fence can prevent elephants coming into the village?

☐ no ☐ yes

16. Are you willing to contribute to the cost of an electric fence protecting the village?

☐ no ☐ yes

17. Are you willing to contribute labor for constructing an electric fence protecting the village?

☐ no ☐ yes

Annex 4B

Agriculture Fence Monitoring

Fence Name: .....

Team: ..... Date: .....

Time Start: ..... Time End: .....

Voltage at Post # * *

1	50	100 .....
150	200	250 .....
300	350	400 .....
450	500	550 .....

* * Decide on Post # based on the number of posts used in your fence, to check the voltage of your fence about 10 times.

Note: Record the signs of elephant presence next to the fence (dung/footprints) in the 'comments' column of the table.

			Post at angle		Post fell						Live wire touching				Comments
Incident No.	Post start	Post end	In	Out	In	Out	Object fell on fence	Wire loose	Wire broken	Plants touch wire	Ground	Post	Water	Earth wire	
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
18															

Annex 4C

Questionnaire for Assessing Fence Effectiveness (After Fence)

Interviewer: ..... Date: .....

Name: .....

Village: .....

GPS: N .....º..... E .....º .....

1. What is the extent of the field cultivated by you?

2. What are the problems you have for cultivation? Please prioritize.

- ☐ insufficient water .....
- ☐ insufficient capital .....
- ☐ insufficient land .....
- ☐ plant diseases .....
- ☐ insect attacks .....
- ☐ birds .....
- ☐ wild animals .....
- ☐ other (specify) .....

3. What crops are cultivated by you?

Name	Extent (Area or Number of trees)
……	……
……	……
……	……
……	……
……	……

4. What was the value of crops you obtained from your field in the last year?

……

5. Did you suffer any crop losses from wild animals within the past year?

☐ yes ☐ no

6. *(if 'yes' to Q5 above)* Which three species caused most damage? Please prioritize.

☐ pigs	……	☐ rats	……
☐ monkeys	……	☐ hares	……
☐ deer	……	☐ birds	……
☐ elephants	……	☐	……
☐ porcupines	……	☐	……

7. Are there elephants in this area?

☐ yes ☐ no ☐ not sure

8. How do you feel about elephants being present in this area?

- ☐ good
- ☐ moderate problem
- ☐ no opinion
- ☐ major problem
- ☐ minor problem

9. If a problem, why? Give up to three answers and prioritize.

- ☐ crop damage ……..
- ☐ human deaths ……..
- ☐ property damage ……..
- ☐ loss of safety ……..
- ☐ human injuries ……..
- ☐ ……..

10. What should be done about the elephants in this area?

- ☐ nothing
- ☐ shoot problem elephants
- ☐ translocate problem elephants
- ☐ shoot all elephants
- ☐ translocate all elephants
- ☐ ……..
- ☐ village electric fence

11. Did you have crop loss in your home garden from elephants in the last year? If so, how many times?

☐ no loss ☐ 1 x ☐ 2–5 x ☐ 6–10 x ☐ > 10 x

12. If you had crop loss, what is the total value of crops damaged? ……..

13. Do you think the electric fence is a success?

☐ no ☐ yes

14. Are you willing to continue contributing to the fence maintenance fund?

☐ no ☐ yes

15. Are you willing to continue contributing labor for maintaining the electric fence?

☐ no ☐ yes

References

Evans, L. 2013. "Elephants Breaking Electric Fences." *YouTube* video, 1:15. Space for Giants, January 25. https://www.youtube.com/watch?v=C9gzAcekEdA.

———. 2014. "Fencing the Frontline: The Separation of Elephants from Cultivation with Electrified Fences." Unpublished PhD thesis, Department of Geography, University of Cambridge, Cambridge, U.K.

Mutinda, M., G. Chenge, F. Gakuya, M. Otiende, P. Omondi, S. Kasiki, et al. 2014. "Detusking Fence-Breaker Elephants as an Approach in Human-Elephant Conflict Mitigation." *PLoS ONE* 9 (3): e91749. https://doi.org/10.1371/journal.pone.0091749.

Palminteri, Sue. 2017. "Breaking a Fence-Breaking Habit: Maintaining the Fences that Reduce Human-Elephant Conflict." *Mongabay* (blog), June (accessed on March 7, 2019). https://news.mongabay.com/2017/06/breaking-a-fence-breaking-habit-maintaining-the-fences-that-reduce-human-elephant-conflict/.

Thouless, C. R., and J. Sakwa. 1995. "Shocking Elephants: Fences and Crop Raiders in Laikipia District, Kenya." *Biological Conservation* 72 (1): 99–107.

Wild Elephant. 2018. "Smart Elephant Breaks an Electric Fence." YouTube video, 1:43. Wild Elephant, May 17. https://www.youtube.com/watch?v=APKmSgVVXoI&feature=youtu.be.

A GLOBAL PARTNERSHIP ON WILDLIFE CONSERVATION
& CRIME PREVENTION FOR SUSTAINABLE DEVELOPMENT

GLOBAL WILDLIFE PROGRAM

ADB · gef · UNDP · UNEP · WORLD BANK GROUP

CITES · ICCWC · IUCN · TRAFFIC the wildlife trade monitoring network · WCS · WILDAID · WWF

www.worldbank.org/global-wildlife-program

Contact: gwp-info@worldbank.org