Human-Elephant Conflict in Asia

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Summary

Human-elephant conflict (HEC) is a complex interaction between humans and elephants, and represents the detrimental impact both species have on each other. However, for the purpose of this project, the use of the term 'HEC' will imply the detrimental impact that elephants have on humans. This takes the form of crop raiding and property damage, and also involves manslaughter and injury to people. The most common negative interaction between human and elephants in this context is crop raiding. Consequently crop raiding will be the most referred to aspect when HEC is mentioned. Any adverse impacts humans have on elephants will be specifically mentioned.

HEC has been identified as a major threat to elephant conservation by all Asian Elephant Range State governments (AsERSM, 2006). All 13 Asian Elephant Range States have experienced HEC and loss of human life due to elephants. Elephant deaths due to retaliatory killing by people have been reported by most Range States (AsERSM, 2006). HEC adversely affects the people who live in and around elephant habitat. It also adversely affects elephants and undermines efforts to conserve the species. The greatest danger HEC poses to elephants is the antagonism it generates among local communities towards elephant conservation. If elephant conservation is to succeed in Asia, then HEC will have to be resolved, or the conflict minimized to the point where it becomes tolerable to local communities.

There are two main constraints in planning and implementing HEC mitigation; one is the absence of a problem analysis guide that helps people work through the complexities of HEC to determine the multiple levels at which different types of interventions are needed. Second is the absence of a comprehensive information source on the different methods (interventions) available for conflict mitigation and how they need to be implemented. Additionally, in the absence of such a document, gaps in our collective conservation knowledge cannot be determined. This results in science being stuck in a cycle where replication of poorly designed studies is common, comprehensive approaches to resolving ambiguity are lacking, gaps in knowledge are not identified and hence not studied, and research priorities are not identified.

The goal of this project was to review existing HEC mitigation efforts in all 13 Asian elephant range countries by reviewing documents, research papers, and meeting reports about HEC, synthesizing the information, and preparing a comprehensive guide that identifies the best approaches and methods to mitigating HEC and acts as the basis for planning and implementing HEC mitigation efforts. This document can also effectively channel research to cover gaps in knowledge on HEC and its mitigation across Asia.

Background

Asian elephants are listed in the 'Endangered' category in the IUCN/Red List (IUCN, 2008) and in threat of local extinction in some range countries. Threats such as habitat loss, fragmentation of elephant populations, human elephant conflicts (HEC), and the illegal killing of elephants require various efforts to ensure the conservation of Asian elephants.

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HEC and loss of human life due to elephants. Elephant deaths due to retaliatory killing by people have been reported by most Range States (AsERSM, 2006). HEC adversely affects the people who live in and around elephant habitat. It also adversely affects elephants and undermines efforts to conserve the species. The greatest danger HEC poses to elephants is the antagonism it generates among local communities towards elephant conservation. If elephant conservation is to succeed in Asia, then HEC will have to be resolved, or the conflict minimized to the point where it becomes tolerable to local communities.

While HEC mitigation has been a major component of elephant conservation and wildlife management across the Asian elephant range for the past several decades (AsERSM, 2006), the problem has not been resolved so far. The problem has not only persisted but has escalated over time. For example, in Sri Lanka nearly 150 elephants were being killed annually in the 1950s and this has remained true even in the late 1990s (Desai, 1998); most of the deaths were conflict related. In India, Project Elephant, a project dedicated to the conservation of elephants in the country, spends nearly 60 to 70% of its budget directly or indirectly on HEC mitigation. In spite of this HEC has escalated and the number of people killed by elephants is over 400 per year now; it was approximately 200 in the 1980s (Rangarajan et al., 2010). Even at the national level HEC is a serious problem; in India an estimated 0.8 to 1 million hectares of agricultural land is affected by crop raiding by elephants (Rangarajan et al., 2010). This would represent nearly 500,000 to 1 million families being adversely affected by elephants. What is apparent is that far from resolving HEC the conflict situation has become far more serious.

The primary reason for the failure of current HEC mitigation efforts has been the absence of a science-based approach to resolving the problem. HEC mitigation is currently being addressed in an ad hoc and disparate manner. Individual farmers, communities, government officials (wildlife or community related) at various levels, research institutes/NGOs working with people or wildlife, and even individual researchers are all attempting to mitigate HEC. The primary focus of HEC mitigation has been limited to preventing elephants from raiding crops. The complexities of HEC do not allow such a simplistic approach in all cases and that is the major failing for most HEC mitigation efforts. Furthermore, the complexities of HEC have not been taken into consideration in most if not all HEC mitigation efforts and HEC research. In the absence of a comprehensive understanding and approach to HEC mitigation, the bulk of the efforts have failed; HEC has not been reduced across the Asian elephant range.

While a few projects claim successes in their attempt to resolve HEC, these claims themselves are indicators that there is often a failure to comprehend the real issue. Given the large home range sizes of elephants and the size of elephant landscapes, any successes are applicable over only a very small fraction of the landscape or home range. No elephant inhabited landscape has successfully resolved HEC in a meaningful way. The primary focus of HEC mitigation has been limited to preventing elephants from raiding crops. The major reason for failure is the absence of a problem analysis approach that examines and addresses the complex factors that contribute to HEC in a given area.

HEC mitigation efforts have been seriously hampered by two reasons: first, the absence of a comprehensive guide on conflict mitigation that addresses all the complexities of HEC. This has meant that most people start off without knowing which tools are available or how best to apply these tools. And second, by the absence of a critical review of the various conflict mitigation methods that are available across Asia. This results in people being unable to make information-based choices, or being forced to make choices based on poorly analyzed data or poorly designed studies.

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Cover photo: Bull elephant crossing through oil palm plantation in Riau Province, Sumatra.
Photo by Ajay A. Desai, WWF-Indonesia

Acronyms and Abbreviations

EIA – Environmental Impact Assessment
HEC – Human-Elephant Conflict
INGO – International Non-Governmental Organization
MER – Managed Elephant Range
NGO – Non-Governmental Organization
NP – National Park
PA – Protected Area

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SECTION 1: Considerations for Human-Elephant Conflict

Much has been written about Human-Elephant Conflict (HEC) in scientific and grey literature. However it is the failure to properly apply this information that results in wildlife managers not addressing the root causes of HEC and remaining focused primarily on addressing the symptoms. Unfortunately the failure to understand and therefore to properly use this information also ensures that the processes that cause HEC persist, forcing wildlife managers to deal with constantly escalating HEC situations. This leads to an erosion of the conservation potential of various elephant populations and ranges across Asia. In order to develop adaptive management plans based on the factors that cause or contribute to HEC, it is important to first understand the context and background of these factors. The goal of this document is to provide a comprehensive understanding of the various factors and considerations in regards to HEC and its management.

Factors that Contribute to Human-Elephant Conflict

The following four factors (1) habitat, (2) elephant population, (3) elephant behavior, and (4) people contribute to initiating, escalating, or sustaining HEC. It is essential to understand how these factors operate in order to manage HEC in a comprehensive manner.

► Habitat factors

Elephants' requirements for space reflect their social organization, their ranging behavior, and their ecological needs. Elephants live in matriarchal societies where females form cohesive groups with strong social bonds and males are solitary but interact with other males and females within their home range. Genetic studies done by Fernando and Lande (2000) indicate that females in a group (clan) are related. A population or sub-population could be composed of several clans and independent males. Clans have well defined home ranges and show strong fidelity to these ranges; all clan members show coordinated movement within the clan's home range. Clans may also have well defined seasonal ranges within their home range and also show strong fidelity to these and to the routes they use to move between them. Home ranges of different clans may overlap partially or totally, but there is temporal separation in resource use which is governed both by availability of resources and dominance hierarchies.

While elephants are extreme generalists, having adapted to habitats that range from dry thorn forests to wet evergreen forests, they are finely tuned to the spatio-temporal variations in the resource availability within their home ranges and have very specific strategies to exploit them. Baskaran (1998) has shown that even when there is 80% overlap between the home ranges of different clans, the use of different vegetation types and food plant species varies significantly. Wildlife managers need to realize that they are dealing with very specific social units that are fixed spatially and cannot be moved around freely.

Clans are likely to leave their home ranges only when exposed to severe stress such as extreme droughts, severe poaching, overpopulation, severe human disturbance, or when the habitat within a home range is lost or highly degraded. The entire clan or a part of it may break away and

Elephant herd moving into agricultural area, Assam, India. *Photo by Jayanta Kumar Das*

disperse in search of better habitat and such movement is an indication that there are serious problems. Studies in South India indicate home range sizes as large as 600 km^2 for females and 350 km^2 for males (Baskaran et al., 1995), while a study in North India indicates home range sizes of 184 to 327 km^2 for females and 188 to 408 km^2 for males (Williams et al., 2001). In Sri Lanka, home range sizes from 29 to 160 km^2 for females and 53 to 345 km^2 for males have been reported (Fernando et al., 2005). While some smaller home ranges have been observed, these smaller sizes are likely representative of clans with compressed home ranges due to habitat loss or competition. This would indicate that habitat patches less than 250-300 km^2, even when having suitable shape/structure, would be barely enough to hold an undisturbed home range. Desai (1991) and Baskaran et al. (1995) have shown that even when there are large clusters of PAs, the home ranges of all clans and males are not necessarily protected and parts of some home ranges extend into areas outside PAs; similar inference can be drawn from the work by Fernando et al. (2005).

Wildlife managers need to view spatial requirements of elephants in terms of the spatial needs of clans and males that have fixed and well defined home ranges, rather than as space per se. Given that there is not enough data on spatial requirements of elephants across their Asian range, conservation needs are best served (at present) when large, intact, and undisturbed habitat patches are conserved so that there is greater possibility that long-term needs are more likely to be addressed. Because elephants are adaptable, long-lived, and capable of withstanding a lot of environmental stress (especially adults and sub-adults), they will persist in fragmented and poor quality habitat or in small isolated habitat patches for decades. In such situations, elephant presence, even at high densities, should not be viewed as an indication that all is well or that the habitat is suitable or adequate. Such unsuitable areas are likely to represent population sinks, where environmental stress coupled with HEC will eventually result in the extirpation of marginalized populations.

Habitat loss has always been a problem for Asian elephant conservation. The estimated original range of the Asian elephant was 9 million km^2 but it has declined to about 500,000 km^2 today. It was mainly in the second half of the last century that the problem accelerated and became very serious. This period ties in with the rapid growth of human populations and economic development in Asia. Forest cover in Sri

Lanka declined from 44% in 1956 to 22% in 1988. In Peninsular Malaysia and Sabah, forest cover was 90% in the early 1990s but it declined to 58% in Peninsular Malaysia and to 45% in Sabah in 2000. Cambodia saw a rapid decline of forest cover from 73% in 1970 to 53% in 2000. Similarly, Lao PDR saw a decline in forest cover from 73% in 1970 to 47% in 1981. Myanmar's forest cover declined from 47% in the mid-1970s to 36% in 1988. In China's Xishuangbanna National Nature Reserve, which contains 80% of China's elephants, forest cover declined from 70% in the 1950s to 26% in 1980. In India, during the period 1991-99, nearly 1800 km^2 of forest (mostly elephant habitat) was lost in Northeast India (Forest Survey of India, 1999).

Habitat degradation remains a major threat in Asia and can take the form of direct removal of resources useful to elephants, e.g. grass and trees that are reduced or removed by cattle grazing, fires, as well as fuel wood and timber harvesting. Degradation can also take place when human activities bring about structural changes in forests rendering them unsuitable for elephants. Examples of such structural changes include repeated forest fires which can change composition of the vegetation, introduction of exotic weeds interfering with growth and establishment of native vegetation, and frequent slash and burn agriculture which could result in only degraded scrub forests regenerating. Slash and burn agriculture remains a major threat to elephant habitat in some parts of Asia. From 1987-97, approximately 17,300 km^2 of forests in Northeast India were exposed to slash and burn agriculture, of which at least 50% was elephant habitat (Forest Survey of India, 1999). Human presence in the forest can be a major source of disturbance to elephants; Desai and Baskaran (1996) showed that ranging behavior can be adversely influenced by human presence.

Unplanned and diffuse development that causes habitat loss also results in **habitat fragmentation** as it breaks up large habitat patches into smaller fragments. In the absence of a mechanism that monitors and guides development while taking into account elephants, most development has resulted in compounding the problem of habitat loss with the problem of habitat fragmentation. Another threat that is increasingly felt is linear development which most often takes the form of human settlements and agriculture along roads or rivers. While the actual amount of habitat lost may be small, the impact is severe as it results in habitat fragmentation and often denies access to critical resources (i.e. water). With transport needs rapidly expanding in the Asian elephant range countries, roads are being upgraded into multilane highways with heavy traffic that do not allow elephants to cross. Similarly railway lines, irrigation canals, pipelines, and other linear constructions that act as barriers to free movement result in the fragmentation of elephant habitat. The danger lies in the fact that the true impact is not recognized due to the small extent of habitat that appears to be lost to such development. Such threats were identified in northwest Sri Lanka, where Desai (1998) showed that linear development resulted in the home ranges of several clans and males being fragmented into 2 or more habitat patches. In such situations, elephants cannot move across their home ranges without trampling through agricultural and human use areas, thereby exacerbating HEC issues.

Another important issue that needs to be considered is the shape of the fragmented habitat patch. Unplanned development can leave behind habitat patches that are not always well-shaped and are therefore not suitable for elephant conservation. For example, a habitat patch that is 20 x 20 km is better than one that is 4 x 100 km though both have the same area (400 km^2). So wildlife managers should recognize that along with size, shapes of habitat patches are crucial. Desai (1998) has shown that many PAs in Sri Lanka cannot function as stand-alone elephant conservation areas because their poor shapes do not allow normal intact home ranges to be contained within them.

► Elephant population factors

In some regions, elephant populations seem high or at least to have adequate numbers; but the situation may in fact be a disadvantage. Local overabundance (either due to an increasing population or to reduced habitat) of elephants in a particular area can affect HEC, so it is important to understand which factor is at play and what needs to be done to manage this problem. Overall in Asia, the absence of studies focusing on local elephant overpopulation indicates that this issue has been largely ignored. It may become a serious problem in some areas in the near future, as it has the potential to degrade habitat and adversely affect biodiversity, especially in areas that are already facing biotic pressure from the surrounding human population.

Local overabundance due to population growth

Local overabundance is the result of either a growing elephant population within a defined area, or is the result of compression of populations when habitat is lost or fragmented. A growing elephant population can have a detrimental effect on habitat and needs to be taken into account by wildlife managers. In South India, Sivaganesan and Sathyanarayana (1995) found that tree species that elephants feed on in the deciduous forests were rapidly declining due to elephant pressure. While regeneration may also be suppressed due to browsing by deer and due to fires, the mature trees clearly showed signs of overuse. In the same area, Daniel et al. (1987) demonstrated that the elephant population was growing despite poaching of males. By 2000, the population in this area had nearly doubled (Baskaran & Desai, 2000).

Local overabundance due to compressions brought about by habitat loss or fragmentation

Elephants can have an adverse impact on their own habitat (and that of other species) when present at high densities. Given the extensive loss and fragmentation of habitat in Asian elephant range countries, it is likely that many of the existing populations represent compressed populations with elephants living at higher densities than normal. This would be especially true for areas where poaching is not a serious problem. The issue of local overabundance, though recognized as a problem for many years (Balasubramanian et al., 1995: Baskaran & Desai, 2000), has generally been given little attention by wildlife managers. However, the conservation community (wildlife managers and others) should not ignore the problem and must recognize the fact that there is an urgent need for further research, planning, and action to tackle this problem.

► Elephant behavior

Elephant behavior links directly to habitat and elephant population related issues; an understanding of how these components are connected allows wildlife managers to take actions that result in stopping new HEC, stopping the escalation of existing HEC, or help efforts needed to mitigate HEC. Wildlife managers often fail to take these factors into account when assessing and planning HEC mitigation. This has resulted in addressing the symptoms rather than the causes, while at the same time allowing the causative factors to escalate further. It is time to shift to dealing with HEC in a systematic and holistic manner.

Studies in South India by Balasubramanian et al. (1995) show that only some female family units and some adult males raid crops; but not all elephants are crop raiders. Data from Fernando et al. (2005) and Williams et al. (2001) in other regions support this assessment. However, in cases where elephant populations are severely compressed into small habitat fragments, the resulting high densities and/or the significant levels of habitat fragmentation affect all elephants in that area, and then all elephants may be likely to raid crops.

Social organization of elephants and its implications for HEC

Within an elephant population, elephants live in well-defined family units or clans comprised of adult females, as well as sub-adult and juvenile males and females; adult males (bulls) are primarily solitary. Members of a clan are believed to be related, associate regularly, and show coordinated movements. Male elephants leave their natal clan after reaching puberty and do not show strong bonds to clans or other adult males; however they will join clans for breeding (Baskaran et al., 1995).

Balasubramanian et al. (1995) determined that while bulls appear to raid crops more frequently than herds, the damage caused by female herds is greater than that caused by bulls. As adult bulls are primarily solitary, they often raid crops alone. Young males that are establishing their own home ranges after leaving their natal clan may end up in or around agricultural areas and become crop raiders by associating with other animals that raid crops. However female herds have strong social ties and when raiding crops they operate as a single unit comprised of multiple individuals.

Wildlife managers need to address HEC caused by both bulls and clans. Individual problem elephants or clans need to be identified and action taken directed towards them specifically. If removal of problem elephants is considered, the removal of non-raiding elephants or clans will not reduce HEC. In situations where conflict is primarily caused by bulls, the sex ratio within the population should be considered as in areas with low numbers of bulls (e.g. due to poaching) their removal is not advised.

Ranging behavior of elephants and its implications for HEC

Desai and Baskaran (1996) showed that the elephant population sub-units (clans and solitary bulls) have different strategies for habitat utilization with well-defined home ranges; this includes the use of seasonal ranges within home ranges, and regular routes or migration paths within these seasonal ranges. Elephants show great fidelity to these home ranges, which along with their spatiotemporal use of the range, is based on resource availability and dominance hierarchies. Thus human impact affects different sub-units (clans and bulls) differently, depending on the location of their home ranges, of their seasonal ranges, of the migration routes, and the degree and type of use of the interface area by individual sub-units. It is important to consider that raiding and non-raiding clans and bulls have overlapping home ranges.

The availability of water is a major factor that governs elephant distribution and range utilization. Clans and bulls with normal (not modified by humans) home ranges significantly prefer areas closer to water rather than away from water. In deciduous forests in particular, water sources are sporadically available and this results in patchy use of the habitat by elephants.

Clans and bulls whose home ranges have not been significantly disrupted and whose ranging and behavior remains normal will avoid using areas around human settlements. Human settlements and activity within the elephants' habitat has a detrimental impact on elephants by rendering the surrounding habitat unusable to elephants. Human settlements not only deny the use of significantly large areas, they also deny the use of significantly important (preferred) areas for elephants. The elephants' social organization and home ranges break down only when they are exposed to severe stress. It is therefore important to assess and understand, in any given area, the importance of home ranges and corridors that facilitate movement of clans and bulls between seasonal ranges to avoid conflict with humans.

Ecology of elephants and its implications for HEC

Detailed ecological studies should be carried out to properly support PA and HEC management

planning. Across Asia, poor habitat quality, due to loss and fragmentation, and the increasing competition for resources are pushing larger numbers of elephants into human use areas, thereby increasing HEC. Such loss and degradation affects only those elephants within whose home range the loss and/or degradation have taken place. The compression of elephants into smaller areas or by increasing populations may result in 'unaffected' (by loss and/or fragmentation) elephants adjusting their home ranges and consequently coming in contact with human use areas.

The growing human population and the increase of human activity and/or settlements results in an expansion of areas influenced by human impact, placing an increasing demand on surrounding natural resources. Elephant conservation areas are becoming smaller and both population and habitat management is required if these areas are to remain viable. Human settlements have a dual impact on elephant habitat (Desai & Baskaran, 1996). The directly visible and measurable impact is that of habitat loss through conversion of elephant habitat for human use. The second impact which is equally, if not more, harmful but rarely visible is that of area denial. Human influence on elephant habitat extends well beyond the boundary of human use areas (village and agriculture) into the surrounding elephant habitat. Normally ranging clans and bulls significantly avoid areas close to human settlements, resulting in vast areas being denied to elephants. In addition, human settlements are almost always in close proximity to water sources as humans are also dependent on water. Areas close to water are the preferred areas for elephants and the loss of such areas has a much more serious impact on elephants than the loss of areas away from water. Human settlements not only deprive the elephants of the use of significantly large areas of habitat but also deprive them of significantly preferred habitat.

Wildlife managers should ensure that new settlements or developments are not allowed within or adjoining protected areas as the actual detrimental impact of a settlement extends well beyond the settlement boundary. New settlements should be attached to existing human use areas rather than creating new enclaves as these would have larger perimeters, therefore increasing the area of interface and creating problems leading to HEC in the new areas.

Socio-economic considerations often preclude the inclusion of home ranges of all elephants using PAs into a protected area network (Baskaran et al., 1995). However, at a minimum, the home ranges of those clans that form a sizeable part of the population and spend a large proportion of their time within the PA should be protected. This means assessing administrative boundaries so they align with ecological boundaries of these clans in order to better protect habitat within their home ranges.

► Human factors

A significant cause for failure of HEC mitigation measures has been the inability to incorporate the various human related factors that need to be considered. HEC occurs because people live and practice agriculture in or near elephant habitats, and elephants raid crops that are grown by these people. By removing one of the components (people/crops or elephants) from this equation HEC can be stopped. The factors that bring and keep people in areas that are prone to HEC need to be identified and managed.

Legal issues

HEC mitigation is largely seen as a tool that facilitates elephant conservation with some attention given to alleviate human suffering. However there is little attention given to the legal implications or legal obligations that conflict situations impose on wildlife managers. It is possible that opportunities to develop better HEC mitigation options are missed because of this lack of information and knowledge of legal implications. Legal issues are not limited to illegal conversion of elephant habitat, breakdown in law enforcement, governments not adhering to their own environmental laws and diverting habitat to

human uses without understanding the impact. More importantly there is a need to focus on the legal obligations of affected parts of the human population, i.e. farmers directly affected by HEC. From a legal perspective there is no obligation on their part to do anything about HEC because a public owned animal is causing personal loss, and there is no legal provision that wild animals are "allowed" to intrude into human use areas. There needs to be a shift away from the mindset that only farmers need to be responsible for mitigating HEC. The responsibility of managing HEC falls on various stakeholders (i.e. government, farmers, communities, companies, NGOs, etc.) to cooperatively work to address HEC.

Changing perceptions and tolerance

The implications of changing socio-economic aspirations of the people, the opportunities and constraints of HEC politicization, all of these aspects have an influence (direct and indirect) on peoples' response to HEC and its mitigation. The increased access to media and information via newspapers, TV, and to social media via the internet has created a greater awareness about better standards of living and peoples' rights to a better life. This leads to increased social and economic aspirations making people less tolerant of losses brought about by elephants.

Absence of or poor application of crop protection measures

Situations where crop raiding can be managed but is not are usually due to a **capacity related issue.** The effectiveness of crop protection measures is related to the effort put into them. When there is no clear understanding of the principles of implementing and maintaining tools such as guarding and barriers, the methods often fail. Barriers such as electric fences can be effective to limit HEC, but only if there is a sufficient training about providing proper maintenance as well as combining the barrier with other protection measures (i.e. guarding). A one-time assistance by government and/or non-government agencies to agricultural communities by supplying and installing a crop protection tool such as an electric fence with improper training, and no continued monitoring and support has led to the failure of effective crop protection tools. Farming communities are often not well organized nor adequately committed to cooperative crop protection efforts. They also lack technical knowledge to repair equipment and do not have access to manufacturers or service centers. Where there is a poor understanding of the methods, and no efforts to maintain available equipment in good working order, these crop protection measures will fail. As such, efforts to support crop protection measures need to consider that along with providing financial support to purchase equipment or tools, it is also essential to build the capacity of the local communities to understand how to apply, maintain, and monitor the applied measures for effective crop protection.

Inadequate or inappropriate crop protection measures

Situations where crop raiding has escalated to a point where the application of suitable crop protection measures is beyond the capacity and/or resources of the local communities is usually a **resource related issue.** Agricultural communities in HEC prone areas often do not have the resources to adequately protect their crops. If these communities have been long established in elephant areas they may be more tolerant of a certain amount of crop raiding. When farming communities are recently established in elephant areas, with no prior knowledge of dealing with HEC, this can be problematic. Firstly, elephant naïve communities should be informed and trained about various crop protection measures. If they are supported to develop such measures, these should be reasonably simple to understand and implement and should require that a minimum amount of the farmers' resources be diverted to such measures. Unfortunately many times either government or non-government agencies do not present the measures in a manner to gain adequate community support so the resulting efforts are ineffective, even inappropriate for the particular situation due to a lack of training and resources.

Key Considerations

Factors that Contribute to Human-Elephant Conflict

- The following four factors contribute to initiating, escalating, or sustaining HEC: (1) habitat, (2) elephant population, (3) elephant behavior, and (4) people.
- There is not enough data on spatial requirements of elephants across their Asian range, so conservation needs are best served (at present) when large, intact, and undisturbed habitat patches are conserved so that there is greater possibility that long-term needs are more likely to be addressed.
- Habitat degradation takes place when human activities bring about structural changes in forests rendering them unsuitable for elephants.
- Elephant behavior links directly to habitat and elephant population related issues, and wildlife managers often fail to take these factors into account when assessing and planning HEC mitigation. Wildlife managers need to realize that they are dealing with very specific social units that are fixed spatially and cannot be moved around freely.
- Earlier studies show that only some female family units and some adult males raid crops; but not all elephants are crop raiders.
- The availability of water is a major factor that governs elephant distribution and range utilization.
- Human settlements not only deny elephants the use of significantly large areas, they also deny the use of significantly important (preferred) areas for elephants.
- Detailed ecological studies should be carried out to properly support PA and HEC management planning.
- A significant cause for failure of HEC mitigation measures has been the inability to incorporate the implications of the various human related factors that need to be considered.
- The factors that bring and keep people in areas that are prone to HEC need to be identified and managed.

Types of Human-Elephant Conflict Situations

There are four classifications – 1) habitat and population, 2) elephant behavior, 3) interface area, and 4) intensity of HEC – that all need to be evaluated to determine the type of HEC mitigation approaches needed in a particular area. In planning comprehensive HEC mitigation, the first step is to identify needed actions and constraints for each situation.

1. HABITAT SIZE AND POPULATION DENSITY BASED CLASSIFICATION

The implications for HEC mitigation and long-term conservation of habitat size and resident population density need to be assessed for each type of habitat:

» Adequate and reasonably intact habitat (with low/moderate/high elephant densities)
This area would be an intact habitat patch of varying size (Large = 1000+ km^2; medium = 500 – 1000 km^2, and small = 250 – 500 km^2). These numbers may vary regionally and need to be discussed; their implications to HEC and its management should be clearly understood.

» Fragmented habitat (with low/moderate/high elephant densities)
These would be areas where elephants move between patches of habitat. Individual patches may not be greater than 250 km^2 (see above for sizes greater than that), but the cumulative area used by elephants is greater than 250 km^2. There is a need to identify a minimum size for individual patches, and for the total area of all patches used by elephants in a particular area.

» Habitat patch (with low/moderate/high elephant densities)
In this type of habitat elephants are confined to a single patch or several patches that are less than 250 km^2. This type of habitat patch may be inadequate to support the existing – or a viable - pocketed elephant population.

Elephants crossing railway tracks in Mahananda Wildlife Sanctuary, West Bengal, India.
Photo by Debapratim Saha

2. ELEPHANT BEHAVIOR BASED CLASSIFICATION

A better understanding of elephant behavior and why they raid crops will help decide what type of mitigation action is needed in a specific area. Elephants raid out of necessity and not as a foraging strategy. The need to raid crops is a result of loss or degradation of part or most of their home range, to a point where resources may no longer support them. Generally only clans significantly affected by loss or degradation of their home range will raid crops; those who are not severely affected usually do not raid. Predictably, areas with higher habitat loss or degradation usually see increased HEC. A noteworthy consideration is that elephants damage crops by both eating and trampling. It is important to consider that one, more, or all of the following situations could exist in the same area:

Opportunistic crop raiding occurs where crop protection is absent or very poor and there is little or no human disturbance; in those situations elephants with access to unprotected crops will raid, as they see cultivated crops as a concentrated source of food. This type of crop raiding is common in all agricultural areas in and around elephant habitat. This is the most easily managed type of HEC, and stopping these elephants from crop raiding has no adverse impact on their well-being. Proper guarding techniques or even minor barriers are sufficient to limit such crop raiding. However, some opportunistic raiders can become habitual crop raiders if allowed constant and easy access to crops.

When opportunistic raiders get used to ineffective or routine crop protection measures they can become **habitual raiders**. Habitual crop raiders are animals that have lost most or a significant part of their fear of humans and of usual crop protection methods. They are also animals that have learned to negotiate barriers. They recognize that crops are a good source of nutrition and are available for easy access. These elephants are as persistent and problematic as obligatory crop raiders.

In cases of **obligatory crop raiding**, elephants have inadequate or no resources in their home ranges and are dependent on raiding for much of their food needs. When habitat loss, fragmentation, or degradation severely reduces the size or quality of the habitat within a home range, the affected elephants will raid crops out of necessity. The severity of crop raiding will depend on the extent of habitat that has been lost or degraded. For these animals the only alternative to crop raiding is slow starvation due to the scarcity of natural food resources. These elephants are difficult to contain and, even if they are contained, there is a need to fully understand the conservation implications of confining such populations using barriers and how best to deal with such animals.

There is a need to understand and address the issue of **dispersing populations** (clans or bulls) both in terms of allowing re-colonization of past ranges where possible, and in terms of preventing or stopping elephant dispersal where it is problematic. When a home range or the social organization of an elephant population is severely disrupted, an entire clan or a part of the clan may break off and disperse in hope of finding a new, more suitable area. Males also disperse as a natural part of their social behavior. However males, like clans, may disperse out of their normal range when conditions become extremely poor. The primary reason for such dispersals is severe disturbance in the original range and is a clear indicator of serious problems in that range. Such dispersals cause significant HEC problems for two reasons: first, there is generally no suitable habitat outside existing elephant range, and the probability of finding suitable habitat patches is remote due to low forest cover. These elephants therefore become totally dependent on crops for their survival. Second, people living in the newly colonized areas are generally not knowledgeable about elephants or dealing with HEC. In areas where dispersals have occurred there is often a high cost in terms of human and elephant lives, yet no clear policy has been developed to address these situations.

As dispersals are likely to continue to occur across Asia, even increase in frequency, it is important to support development of a policy regarding this issue. If elephants are allowed to disperse, the policy should clearly include the need to allocate resources to manage the elephants in the new area, as well as building capacity of staff in that area. If dispersals are not allowed, the elephants will need to be contained in suitable areas via barriers. There may also be a need to translocate elephants that have already dispersed back to their original habitat and then contain them via barriers. The policy can also allow decision making based on the availability of habitat in the new area and ensuring that conflict is prevented.

3. INTERFACE BASED CLASSIFICATION

When managing HEC the implications of various types of interface or boundary areas need to be addressed:

» Hard and clear boundaries

Hard or clear boundaries are distinct boundaries between human use and elephant habitat areas. Such boundaries are not easily negotiable by elephants. Conflict along such boundaries is also generally low unless there has been large-scale displacement of elephants. Distinct boundaries lend themselves to the installation of elephant proof barriers, they reduce the manpower required to guard the boundary, and they reduce the costs associated with crop protection as they greatly diminish the length of the interface area. Hard boundaries are mostly seen in PAs that have been well defined.

» Diffuse boundaries

The most common interface between human use and elephant habitat areas is a diffuse boundary where the margin is not clear. This is typical in areas with high levels of encroachment. Diffuse boundaries are not conducive to effective HEC mitigation measures involving barriers or fixed deterrents as there is no clear boundary where the barrier can be implemented. These boundaries create a mosaic of human use areas and elephant habitats, which ensures that elephants constantly encounter human use areas, thereby increasing the probability of conflict. As boundaries are not clear, HEC is generally very severe along this type of interface.

4. INTENSITY BASED CLASSIFICATION

An important component to HEC is measuring and understanding the severity in its various human-related dimensions:

» Impact on the quality of life

HEC negatively impacts human well-being. While the immediate and most visible impacts are loss of crops, property damage, physical injury or loss of life to people sharing space with elephants, there is little information about the less visible impacts of HEC, particularly on the psycho-social well-being of rural, agricultural communities (Jadhav & Barua, 2012). In India, approximately 500,000 families across the country are affected by HEC (Rangarajan et al., 2010) and 10,000 – 15,000 houses are damaged annually by elephants (Bist, 2006). These affected families mainly rely on agriculture; as a result of HEC they suffer not only loss of crops but also the loss of already harvested crops when storage granaries or houses are damaged by elephants. The loss of income or food is compounded by a loss of health, both psychological and physical, brought on by the stressors of guarding fields and homes. Elephants generally raid at night *(See Section 3)*, leading

the farmers who are guarding their crops to suffer from a significant lack of sleep. The ensuing fatigue often means less productivity during the day. Jadhav and Barua's (2010) study illustrates how the psycho-social consequences of HEC significantly impact people's well-being. These consequences are not straightforward outcomes of human–elephant encounters; conflicts aggravate pre-existing problems in local communities such as poverty and mental health, while fatalities from elephant attacks during HEC result in domino effects that multiply problems. The authors argue that further studies into the less visible impacts of HEC on human physical and psychological health and well-being are needed to better connect ecology, culture, and clinic.

» Peoples' perceptions

Cultural tolerance for HEC is eroding in Asia. People perceive elephant caused damage as being the most problematic, even though elephants are responsible for a small proportion of crop loss when compared to other causes such as natural disasters or pests (rodents, insects, birds, etc.). While agricultural communities acknowledge that these pests cause more damage than elephants, the perception is that people can eliminate these other pests (even when illegal as the laws are generally not enforced in such cases). Elephants are much more difficult to stop, drive away, or eliminate. People also feel much more threatened by elephants than by smaller pests as they may attack people in their fields or homes, and the fear of encountering elephants is a constant stressor. Elephants can be a long-lived concern as a single sub-adult male can become a local problem for nearly 40 years if it is not properly managed. Elephants are viewed as belonging to the government not only because they are protected but also because government agencies are responsible for their management. As a result, this notion makes people overly dependent on the government to deal with HEC.

» Economic impact

The economic impact of HEC affects agricultural communities who live near or in elephant areas; it also affects government agencies tasked with the responsibility for wildlife and the forest environment, as well as those agencies responsible for rural communities. This impact includes visible costs due to damage to crops, damage to structures such as houses or storage buildings, to fences and other equipment, as well as costs of compensation – which may be paid not only for loss of crops but also for injuries and/or loss of human life. India, for example, spends about US$2.2 - 3.4 million per year on compensation for HEC (AsERSM, 2006). That amount may continue to rise across Asian elephant range countries as development and prosperity have moved people away from subsistence farming and more towards commercial farming where a higher value is put on agricultural losses.

There are also hidden costs of HEC that are often overlooked; the daily stressors due to a constant fear of conflict with elephants can lead to diminished productivity and to health conditions. Costs to the farmers of resulting health care are often not considered. Additionally, the day-to-day costs of crop protection (torches, batteries, fuel, fire crackers, etc.) further cut into resources that could have been better used for improving the quality of life of the farmers. The implications of these losses on the quality of life are generally not measured when economic costs of crop protection are being considered.

» Physical intensity - Frequencies or area damaged

It is important to measure and understand the frequency and area of damage in any given site prior to developing an HEC mitigation measure. Conflicts with elephants vary in physical intensity from site to site. In some regions elephants are prone to entering human use areas often, and the damage caused during each incursion varies from mild to severe. In other situations elephants may enter the human use areas infrequently, but when they do, they may cause a high level of damage, i.e., crop fields are raided only at harvest time causing significant loss for farmers. If the frequency of raiding is low (i.e. seasonal), it may not be worth using resources to protect crops daily, but rather to focus those resources for protection only during the time when elephants are known to raid.

Key Considerations

Types of HEC Situations

- There are four classifications – 1) habitat and population, 2) elephant behavior, 3) interface area, and 4) intensity of HEC – that all need to be evaluated to determine the type of HEC mitigation approaches needed in a particular area.
- The implications for HEC mitigation and long-term conservation of habitat size and resident population density need to be assessed for each type of habitat.
- A better understanding of elephant behavior and why they raid crops will help decide what type of HEC mitigation action is needed in a specific area.
- Elephants raid out of necessity and not as a foraging strategy. The need to raid crops is a result of loss or degradation of part or most of their home range, to a point where habitat resources may no longer support them.
- There is a need to understand and address the issue of dispersing populations as they cause severe HEC.
- The implications of various types of interface or boundary areas between human use areas and elephant habitat need to be addressed.
- An important component to HEC is measuring and understanding the severity in its various human-related dimensions, i.e. impact on quality of life, perceptions, economic impact, and physical intensity.

SECTION 2: Addressing Root Causes of Human-Elephant Conflict

Addressing the root causes of conflict is a basic first step towards HEC mitigation. While the objective of a mitigation plan is to resolve HEC, that can only be done by stopping new HEC, limiting escalation of existing HEC, and reducing existing HEC.

In areas where there is HEC there is an inverse relationship between human welfare and elephant welfare. Ideally for both species, the total absence of the other would be the best. However in a situation where both need to coexist, it remains for people and wildlife managers to strike a balance between elephant conservation needs and human needs. In other words, achieve a suitable intermediate position which is acceptable both to local communities and for elephant conservation. Well thought-out and practical management strategies can extend this intermediate point to give both elephants and people a better deal. In the long run there will be a need to manage elephant populations taking into account the carrying capacity of the habitat, so that conservation and HEC issues are addressed. Both short-term and long-term strategies are needed to address HEC. Short-term strategies or stop-gap methods address immediate HEC mitigation needs and buy time to implement long-term strategies; however, solving the problem effectively requires long-term strategies.

Addressing Habitat Loss, Degradation, and Fragmentation

At the onset, HEC is only present when people remove habitat and replace it with a human use activity such as planting crops. This basic concept is at the root of all new conversions which lead to habitat fragmentation and degradation. Essentially two factors are at play: human modification of elephant habitat and the elephants' response to it. A conflict situation can also be aggravated by the type of interface created between elephant habitat and human use areas. Problems range from numbers of

The interface of agriculture and forest in Bangladesh.
Photo by Heidi S. Riddle

elephants adversely impacted and brought into conflict, to how easy and/or cost effective it is to manage the interface between elephant habitat and human-use areas when it comes to implementing HEC mitigation.

Stopping habitat loss, degradation, and fragmentation would address a major root cause of HEC. To do so requires addressing the problems inherited from the past, and, through effective land use planning, to restructure the boundary between human use areas and elephant habitat. The first step would be to develop regulatory mechanisms that stop habitat loss, fragmentation, and degradation that initiate and escalate HEC. Given the current trend vis-à-vis the use of forest lands for development this becomes critical to HEC mitigation. Stopping or regulating habitat loss requires cross sectoral linkages between various government agencies and long term land use planning. These have to seriously consider habitat and ecological requirements of elephants.

Understanding at what point the loss of habitat and forest cover distinctly affects HEC would assist in developing assessments of management needs to maintain landscapes. A study (Chartier et al., 2011) in Assam, India, determined that the critical threshold of forest cover in that area was 30-40%; when forest cover dropped below that level, HEC in the area transitioned to being far more widespread. A better understanding of the interaction between elephants and their habitat is important for land-use planning given the fact that in the future many elephant populations across Asia are eventually going to be confined to isolated patches of habitat.

► Policy

Across Asia, a stumbling block to conservation and HEC management is the lack of clear policies on elephant conservation and HEC mitigation, yet these issues are high profile for government agencies and for people in the elephant range countries. HEC is a serious and difficult problem that affects many people, and, in the absence of clear policies, management actions will continue to be ad hoc reactions to crisis situations rather than meaningful long-term solutions. If habitat related policies and strategies are to be successful there is a need to recognize the fact that accumulated changes in land use pattern, developmental requirements of the country, and the natural behavior and ecology of elephants impose certain constraints and demand that some basic requirements are met. Such policies addressing habitat issues should take into consideration the following:

- Recognition that habitat loss and fragmentation are the basic causes for HEC, and undue loss and fragmentation of habitat must be stopped. Without this there is little meaning in implementing other HEC mitigating measures.

- Recognition that due to the developmental needs of the country some loss of habitat is inevitable. The participation of government agencies dealing with conservation and of other stakeholders such as conservation NGOs in land use planning and development processes should be mandatory. This is to ensure that, where inevitable, the habitat loss is minimized and is carried out in a manner that has the least impact on elephants. The costs of HEC management as a consequence of the planned development should be included in the development project costs.

- A realistic policy should be formulated recognizing that the accumulated changes in land use pattern do not permit all elephant ranges to be brought under protection, and that it may not be possible to conserve all elephants. The policy should therefore distinguish between elephant populations living in habitat areas that have the potential for medium to long-term conservation, and those in severe conflict with people and living within habitat patches that are too small or fragmented to permit even short-term conservation, i.e. "doomed populations".

► Integrated development planning

Addressing habitat loss, fragmentation, and degradation requires proper land use planning, at the landscape and local level, that takes into account both elephant conservation and development needs. Cross-sectoral land use planning is an important tool in addressing long-term conservation and HEC mitigation needs. Unplanned development has resulted in creating a mosaic of elephant habitat and human use areas with diffuse boundaries between the two. There is a need to restructure the landscape to create hard and clear boundaries, so that the overall landscape and the boundary are more conducive to HEC mitigation. The importance of having conservation needs integrated into the planning and development process is central to stopping ill-advised development that causes HEC and undermines conservation. Where different government departments, private sector organizations, and local communities work in coordination, both developmental and conservation goals can be achieved. For this to be effective wildlife authorities need to be actively and effectively involved in land-use planning at the local, regional, and national levels. The need for standardized mechanisms that facilitate such cooperation and coordination is important.

► Elephant specific Environmental Impact Assessment (EIA)

Where there are justifiable developmental needs, and where habitat loss is inevitable, the conversion of elephant habitat for human use needs to be done in a well-planned manner so as to minimize its adverse impact on elephants and the HEC resulting from that loss. This can be done using an elephant-specific 'Environmental Impact Assessment' (EIA) that stops poorly planned development and, where development is justified, recommends suitable actions to avoid or minimize the adverse impact of the proposed development. Developing and putting into practice an elephant specific EIA process that takes into account the requirements of elephants and people will stop poorly designed development activities. Where habitat loss is inevitable an EIA will help minimize the adverse impact of any habitat loss through proper planning.

► Protected Areas and Managed Elephant Ranges

Across Asian elephant range countries, a significant part of the elephant population and habitat lies outside the PA network and cannot be brought under the PA network for various reasons. Use and management of those areas outside the PA network should be done in a manner that does not result in these areas being lost to elephants. There is the need to define what human activities (exploitation) are compatible with elephant use of these same areas.

Establishing Managed Elephant Ranges (MERs) addresses the need to have large areas managed for elephants without the need to create new or larger PAs. An analysis done by Leimgruber et al. (2003) showed that only 8% of the elephants' range lies within PAs at present. In reality, Asian elephant

range countries have made significant contributions towards conservation in terms of establishing PAs. Thailand has over 20% of its land area committed to PAs, Lao PDR has set aside 14% of its land area as PAs under the National Protected Areas network and has an additional 8% set aside as provincial and district conservation areas. Cambodia and Sri Lanka have set aside 18% and 13% of their land areas as PAs, respectively. In those countries where the percentage of land area under PAs is small, it generally reflects the lower percentage of forest cover in that country; for example India has less than 4% of its land area designated as PAs but this translates into nearly 25% of the good forest cover. Such large commitments to the PA system make it very difficult for these countries to significantly expand the area under the PA network. Some countries have realized this problem and have recognized that the way forward is to designate elephant habitats outside PAs as "Managed Elephant Ranges" (MERs). MERs are multiple use areas where human use and exploitation of the area is permitted but in a manner which does not alienate the habitat to elephants. Ideally MERs should function as habitat corridors between PAs, provide additional habitat outside PAs, or function as stand-alone elephant conservation areas. In all cases, MERs would bring significantly large areas of elephant habitat under a management system that supports elephant conservation. Several countries have already started acting on this approach and India has established MERs under the name "Elephant Reserves" with administrative support, management planning, and funding that directly focuses on elephant conservation.

► Identifying and securing corridor areas

Habitat fragmentation is a serious problem and there is a need to identify, assess, and prioritize connections between resulting habitat patches so that critical and vulnerable corridors are adequately protected. In the context of elephant conservation, the term "corridor" refers to a relatively narrow stretch of land linking habitat patches and is used by elephants. When identifying a corridor it is important to consider both aspects of connectivity, structural and functional, that the potential linkage area may offer between habitat patches (Rangarajan et al., 2010). The home ranges of elephants include seasonal ranges and they are faithful to the same routes when moving between the different parts of their range. In fragmented habitats, they still use connections

Teak plantation in Myanmar. *Photo by Heidi S. Riddle*

between habitat patches that represent the various seasonal parts of their home range. Identifying areas to be maintained as corridors requires a good knowledge of the home ranges of elephant clans and bulls in a given area. The long-term conservation of elephants can be ensured only by maintaining viable populations within viable habitats; these habitats can be maintained by protecting and strengthening existing corridors to link fragmented habitat patches.

Corridors should be areas already used by elephants to move between various parts of their range. When habitat has been lost or fragmented, it is better to choose a corridor that is used more intensely by most of the elephants in the region; it should be used by female groups and by bulls. Identifying and securing more direct links between patches is preferable that considering a longer corridor, or one that is circuitous, or one that would go through difficult terrain where elephants would be reluctant to move (Rangarajan et al., 2010).

Corridors do not need to be areas with good habitat. Wildlife managers and biologists feel that if the habitat within a corridor is of good quality, elephants may remain in these areas and this could lead to additional HEC as most such habitat linkages are already surrounded by human-use areas. Problems created by linear barriers (canals, roads, rail lines, etc.) can be resolved if adequate and appropriate mechanisms are put in place to facilitate animal movement across them. Securing corridors and stopping linear development will help ensure that further fragmentation of habitat does not take place. An important consideration in protection of these identified corridors is that generally they do not have any legal protection.

Asian elephant range countries should be encouraged to develop a country-specific elephant corridor document such as the one developed by Menon et al. (2005), which identifies, maps, and discusses major corridors for all elephant ranges in India.

► Restoring connectivity where possible

Connectivity of habitat is important to allow elephants to move to different parts of their range at different times of the year. When the connectivity is interrupted it is crucial, where possible, to restore connections between habitat patches. Maintaining areas of connectivity is far more effective than trying to restore them. Once encroachment has occurred in corridor areas, the process to restore connectivity is lengthy, challenging, and costly, particularly in cases where large numbers of households may need to move to other areas.

Restoring a corridor allowing elephants to move through a human use area is generally accomplished by either purchasing the land, by a voluntary relocation of people, through community intervention, or by agreement with the landowners. These negotiations generally require economic incentives along with the consideration of land use policies (Rangarajan et al., 2010). It is important to define and make local communities aware of the importance of corridor areas, while discouraging them from any activities that would be a detriment to elephant movement within these areas. To prevent further fragmentation and escalation of HEC, land use policies regarding corridor areas should be clear, practical, and should be enforced.

Key Considerations

Addressing Habitat Loss, Degradation, and Fragmentation

- Stopping habitat loss, degradation, and fragmentation would address a major root cause of HEC.
- Stopping or regulating habitat loss requires cross sectoral linkages between various government agencies and long term land use planning.
- Across Asia, a stumbling block to conservation and HEC management is the lack of clear policies on elephant conservation and HEC mitigation.
- Including an elephant-specific "Environmental Impact Assessment" (EIA) in land-use planning may stop poorly planned development and can benefit people and elephants.
- A significant part of the elephant population and habitat lies outside the PA network and cannot be brought under the PA network for various reasons.
- Establishing Managed Elephant Ranges (MERs) addresses the need to have large areas managed for elephants without the need to create new or larger PAs.
- Connecting fragmented habitat patches by identifying and protecting corridors is critical to maintain adequate range for elephants.

Addressing Agricultural Area – Elephant Habitat Interface

The interface is the common boundary between elephant and human use areas. The interface area and the perimeter length have implications at the landscape and at the village level. Poor interface areas lead to difficult application of HEC mitigation methods or make applying them expensive and prone to failure. Not enough thought has been given to improving the interface area in order to better address HEC.

► Creating hard/clear boundaries

Fragmented landscapes result in diffuse interface and boundaries between human use areas and elephant habitat; these types of boundaries are not conducive to effective crop protection. In fact they contribute significantly to increasing the intensity of HEC. In such areas the only strategy is to stop random habitat conversion and aim for consolidation of elephant landscapes. Where possible, land use changes should be considered so as to develop clear, hard boundaries between human use areas and elephant habitat. This will allow better application of crop protection methods. Such changes are not short-term strategies and require time to implement; it is therefore essential to initiate any such changes at the earliest.

► Creating an interface conducive to HEC mitigation

Clear boundaries between elephant habitat and human use areas are more conducive to applying effective crop protection methods and managing HEC. Identifying and creating boundaries in areas that have been fragmented with no clear definition of margins is best done initially through an analysis of satellite images (including ground-truthing), and land use mapping. Where needed, a workable plan to establish clear boundaries between human use areas and elephant habitat should be prepared. Based on maps and analysis a report should be developed to generate support from the government and other stakeholders of the boundary planning.

In addition to the type of interface, the length of the interface area (perimeter length of human use area or elephant habitat) can influence the intensity of HEC and its management. Convoluted boundaries with lengthy perimeters will increase the costs of applying HEC mitigation measures, increase chances of conflict, and increase the likelihood of elephants encountering the boundary. Unduly long perimeters also increase the area that is exposed to degradation and disturbance from humans. Shorter perimeters reduce the cost of protecting the interface, and minimize the number of affected elephants.

► Changing the interface

There are opportunities to change the interface so that HEC is minimized locally via the following:

Alternate crops

By growing crops that are not preferred food of elephants (e.g. chillies, citrus, etc.) crop damage can be minimized. However even when alternate crops are not eaten by elephants they may get trampled by elephants crossing through the agricultural areas, and the revenue loss is just as significant to the farmer. The option of alternate crops needs to take into account the socio-economic implications and

feasibility of various crops based on local agricultural conditions. Planting alternate crops as buffer between elephants and preferred crops (i.e. paddy) may not have a significant effect unless the buffer crop zone is broad enough (several km.) to prevent elephants from easily reaching the preferred crops. If the alternate crops are grown on a large scale (i.e. tea, rubber, etc.) elephants may still use those areas (i.e. for shade) and HEC can still occur.

Changing land use

Minimizing HEC locally can also be accomplished by changing the use of the land. Modifying land use from agricultural to non-agricultural may help to reduce the frequency of elephants entering into the area. Options for use of the land include revenue earning activities such as tourism, developing handicrafts (i.e. weaving), etc. Any change in land use may only slowly reduce the frequency of elephant visits over time, depending upon what type of crop raiding occurs (i.e. opportunistic, habitual, obligatory) *(see Section 1)*, whether the land is part of a normal (for the elephants) connecting route to various parts of their range, whether any crops are still grown near the land which might encourage elephants to continue to pass through and cause damage to structures. Land-use modifications away from agriculture use also require a significant investment to build the capacity of the local land owners if they had previously only been involved in agriculture. If land-use change is being considered, it is preferable for that change to include a certain amount of land at a minimum; if the area is too small (i.e. only one farmer in a village agrees to a land-use change) then HEC may not be minimized if elephants still cause high conflict due to crop raiding in the general area. For any planned land-use change to succeed in minimizing HEC, developing such a change requires local land owners to cooperatively discuss and agree on issues such as amount of land to be modified, pros and cons of alternative purposes for which the land could be used, what investments (of capacity building and funds) would be needed to effect the change, and whether any proposed new activity would produce adequate revenue.

► Removing the interface

Removing the interface would eliminate the common boundary between humans or elephants that share a same area. There are two basic options to consider in order to accomplish this:

Relocation of village/agricultural areas

Shifting agriculture/settlements out or away from elephant habitat is a possible solution in select cases, and has been done in some elephant range countries in Asia. However there is limited scope as relocations generally involve several governmental agencies, are very costly, and are more apt to be successful if they are voluntary, incentive driven, and target small forest communities.

Removal of elephants

Removing elephants can take the form of a) removal of a few select problem animals; b) removal of an entire population; c) removal of a few elephants to manage the elephant population in a specific area in a manner that suits conservation and HEC management. The removal of elephants has been done in most of the Asian range countries, and is accomplished using one or more of the following options:

» *Translocation*
The translocation of elephants via short drives provides only temporary relief as elephants return to their original range. This option also results in elephants being driven from one village to another, thereby potentially increasing HEC in other areas, so it should not be used as a routine HEC mitigation measure. Long drives or capture and translocation of individual

elephants or groups of problem elephants appear to solve the problem more permanently. However any translocated elephants need to be regularly monitored by the best means possible to ensure they do not cause conflict elsewhere, and to ensure they can be re-captured if needed.

Dispersed elephants can be translocated back to their native habitat, but only when that habitat has been fully covered with barriers so that they do not wander out again. They can also be translocated to other good habitats far away so that they cannot return to their natal range. In such cases (absence of barriers) there is a need for monitoring and intervention teams to ensure that the elephants do not come out of their new range and cause problems or try to return. In reality, translocations may only succeed in shifting the problem of HEC elsewhere.

The conservation implications of translocation are not well known as there is generally a lack of long-term comprehensive monitoring of the translocated animals, of the impact of the move on elephants (those translocated and those in the receiving area), on the habitat in the receiving area, and on HEC. However translocation may offer some conservation gain as these elephants continue to live in viable areas in the wild.

» *Bringing into captivity*

Bringing one or a few problem elephants into captivity permanently can significantly reduce HEC in a specific area, if the individuals to be captured are definitively identified. However, bringing these animals into captivity raises the question of what to do with the animals long-term as there is currently limited demand for large numbers of captive elephants in Asia.

There are no direct conservation gains from captivity as these elephants are lost to wild populations; however the gene pool of these elephants is preserved. Indirect gains may accrue from the use of these elephants to patrol forests for protection or their use in conflict management. The humane management of such elephants is critical and requires quality maintenance standards that are effectively monitored. Long-term resources (financial and administrative) need to be dedicated to managing these captive animals, and this cost needs to be considered prior to any capture.

» *Culling*

Officially sanctioned culling or killing of multiple elephants is not endorsed at present in any of the elephant range countries in Asia. In some range countries, culling of a positively identified individual problem elephant that has caused severe conflict and killed people may be permissible as a last resort; this happens infrequently and should only be considered following due protocols. The option of killing family groups is not supported by ethical, socio-cultural, or legal perspectives in any of the Asian range countries. However it is at times illegally practiced by local people in retaliatory killings.

» *Managed extinction*

There is an urgent need to discuss and resolve the problem of small isolated elephant populations in serious conflict with surrounding human populations; these isolated populations generally have no long-term conservation potential. Such elephant populations often act as sinks for conservation resources with no real long-term benefits. Captures, translocations, etc., are among the options available to resolve this problem, but all these need to be carefully studied to assess their potential impact and effectiveness in resolving the problem in a particular site.

Elephant radio-collared prior to translocation in Bukit Barisan Selatan National Park, Sumatra. *Photo by VESSWIC*

► Special HEC situations

There are situations that bring their own set of problems and are significant enough to warrant being addressed separately. These usually result in the creation of land use that often facilitates HEC and works towards undermining elephant conservation in some areas.

Addressing shifting cultivation

Shifting cultivation uses a technique known as slash-and-burn and is used primarily for subsistence farming in many Asian countries. This system involves clearing a piece of land by setting fire or clear felling, and using the area for growing crops of agricultural importance. Trees and grasses are burned for clean soil; it is believed this helps fertilize the land, but it can leave it vulnerable to erosion. Generally, after a few cycles of cultivation, the land loses fertility and a new area is chosen. The consequences of slash-and-burn techniques for ecosystems are almost always destructive. When biomass is extracted, the residual soil value is heavily diminished for further growth of any type of vegetation. If adjacent plots are treated in a similar fashion, large-scale erosion will usually ensue, since there are no roots or temporary water storage in nearby canopies to stop surface runoff. Thus, any small remaining amounts of nutrients are washed away and no further vegetation growth of any type may arise for some time.

This type of cultivation is detrimental to maintaining adequate forest habitat for elephants and significantly contributes to fragmenting and degrading existing habitat. Furthermore, the burning or clear felling of forested areas drives elephants into these newly existing human use areas and HEC ensues. Therefore, the role of shifting cultivation, when practiced in or near elephant ranges, is significant to HEC.

Addressing issues related to agro-forestry and plantations

Monoculture plantations (i.e. rubber, pulp wood, tea, oil palm, etc.) convert large areas of forests into areas that elephants are no longer able to fully use. While elephants may still use the plantation areas to some degree, either for shade or to feed on grasses growing in these areas, their

presence increases the opportunities of conflict with plantation laborers. Additionally the elephants may damage plantation trees, leading to some economic loss for plantation managers. When elephants have to use plantation areas as part of their range, they are at risk of increased morbidity and mortality, either intentionally or unintentionally, due to the large amounts of caustic substances such as fertilizers and pesticides used in these plantations. These toxins may be found in the soil and water sources, or they may be deliberately mixed into rice or fruit and left out to be consumed by elephants. Large plantations often require large scale irrigation system, which may include drainage canals, and these can be problematic in cases when young elephants fall into ditches or canals.

Key Considerations

Addressing Agricultural Area - Elephant Habitat Interface

- Poor interface areas lead to difficult application of HEC mitigation methods or make applying them expensive and prone to failure.
- Land use changes should be considered so as to develop clear, hard boundaries between human use areas and elephant habitat. This will allow better application of crop protection methods.
- Opportunities to change the interface should be considered so that HEC is minimized locally via alternate crops or by changing land use to non-agricultural activities.
- Removing the interface would eliminate the common boundary between humans or elephants and can be done by either removing people or removing elephants.
- Shifting people out or away from elephant habitat is a possible solution in select cases, but there is limited scope as it is costly and involves multiple government agencies.
- Removing elephants can target a few problem animals or an entire population, and is done by translocation, capture, or culling.
- Monoculture plantations and shifting cultivation are problematic and facilitate HEC.

Addressing Elephant Population Related Issues

While elephant populations in many sites are threatened, there are also areas where local overabundance of elephants is a problem. This problem is often ignored and needs to be addressed. Population numbers in most Asian elephant range countries are based on guesstimates or on estimates using coarse sampling methods. Even in countries with supposedly good estimates, very few areas have actually been sampled using rigorous sampling methods (AsERSM, 2006). The reasons for this poor state of knowledge include difficulties estimating populations in forested habitat, lack of capacity and institutional strength, inadequate resources, lack of political will, and general apathy. Across Asia, populations appear to be increasing in some areas while they are declining in other areas (AsERSM, 2006). Despite poor sampling, often the scale of the change is large enough to allow a reasonable assessment of the status and general population trend.

► Local overabundance due to population growth and due to compression

Defining and assessing overpopulation

While in certain sites current elephant population numbers may be approximately known, sampling of these populations have generally been done after loss and degradation of the habitat had occurred. Therefore the reduced habitat for elephants may have already compressed populations into smaller habitats, leading to overpopulation. The concern about overpopulation was raised years ago (Balasubramanian et al., 1995: Baskaran & Desai, 2000) but to date few studies have addressed this issue. Asian elephants live in a variety of habitats, and the true elephant carrying capacity of many of these habitats is still not well known. To better define overpopulation, further studies on elephant population numbers should be carried out to assess whether a threshold of overpopulation can be estimated for the various habitats in Asia. Such studies would help to define overpopulation, and, where possible, better identify the cause and effects. Population compression and overpopulation need to be recognized and identified, otherwise the potential for increasing HEC due to overpopulation will be significant if the issue is not properly addressed and managed.

Containing population growth

Where elephant populations are increasing due to compression, broader issues of habitat loss and land-use planning are critical to address when formulating population management and containment plans. Where elephant populations are increasing due to natural growth, and this increase needs to be contained, besides the removal (via translocation, capture, culling) of individual animals the use of immuno-contraceptives for in-situ fertility control is a possible option to contain the increase (Fayrer-Hosken et al., 2000) but requires additional research. In the Asian context there would be considerable difficulties in field implementation. Further, effectively limiting or reducing the size of an elephant population via immuno-contraception would take decades; in the meantime HEC will continue.

Managing compressed populations

Elephant populations that are compressed due to restricted home ranges can survive depending on the density of elephants and the suitability of the habitat. However, in the long run the density of such populations may still increase and the habitat quality is likely to decline due to biotic pressure from surrounding human populations and due to impacts from a higher density of the elephant population. This may result in the area becoming less suitable for elephants and will

likely escalate HEC as poor habitat quality and increasing competition for resources may push these elephants into human use areas. Elephant conservation in these smaller areas can be managed; to do so requires both habitat and population management strategies if the populations are to be viable.

► Addressing populations with no long-term conservation potential (doomed populations)

If HEC mitigation is to be accomplished in a scientific and professional manner, the issue of small isolated elephant populations with no long-term conservation value needs to be addressed. This is an issue that often gets sidelined because it is difficult to address or simply because no one wants to raise this contentious topic.

Defining and managing doomed populations

Severe habitat fragmentation across Asian elephant range countries has created several small pocketed or isolated populations that have insufficient and inadequate habitat, and consequently HEC is high in these areas. Such small, isolated populations that are in serious conflict with the surrounding human population have little hope for long-term survival and their future conservation value is questionable. These populations drain resources that could be better utilized in conserving populations with long-term conservation prospects. An assessment about "doomed populations" should only be made after properly applied HEC methods have been tried and shown to have failed. When these populations are identified, management decisions need to consider whether to remove the animals (via translocation, capture, etc.), or to contain the population via barriers to reduce HEC.

Key Considerations

Addressing Elephant Population Related Issues

- Local overabundance of elephants is a problem that is often ignored and needs to be addressed.
- Elephant population compression and overpopulation need to be recognized and identified, otherwise the potential for increasing HEC due to overpopulation will be significant if the issue is not properly managed.
- If HEC mitigation is to be accomplished in a scientific and professional manner, the issue of small isolated elephant populations with no long-term conservation value needs to be addressed.
- When isolated "doomed populations" are identified, management decisions need to consider whether to remove the animals (via translocation, capture, etc.), or to contain the population via barriers to reduce HEC.

SECTION 3: Containing Human-Elephant Conflict

When the factors and root causes of HEC are identified and addressed, HEC may still persist along the interface areas and will need to be contained or minimized even further. Using various measures and tools to contain HEC is the second step in mitigation. This section discusses the two main components of containing HEC, through guarding which includes patrolling, and through the use of barriers and other deterrents.

Guarding

► Origin and current application in HEC mitigation:

Guarding primarily involves farmers guarding their crops at night when elephants and other herbivores are most likely to raid crops. It probably evolved when humans first started cultivating crops in a significant way and started having crop raiding problems. It is likely that guarding has evolved as a response to crop raiding by all herbivore crop raiders and not just as a response to elephants. It would have been the only method available in the past, and has largely remained the primary method of crop protection until recent times. Guarding would likely have involved the use of lethal actions to keep wild herbivores out of agricultural areas, and would also have been a source for procuring meat. Use of lethal or harmful methods while guarding would also have made it more effective in the past. The use of spears and arrows would have been significant deterrents when used in guarding, and the introduction of guns would have only enhanced the deterrence even if guns were not widely available.

Guarding is probably the most common and widely practiced crop protection method in all Asian elephant range countries. Communities traditionally practicing agriculture in or adjoining elephant and wildlife habitats have been practicing guarding as an integral component of agriculture. However, in the last six to seven decades, changes in communities practicing agriculture, laws, and land use have brought about significant changes that, in turn, have led to changes in guarding practices. Many of these changes have resulted in guarding becoming less effective or less applicable in its traditional way as a standalone crop protection method. Though it may appear rather ineffective, its absence also ensures that no crops would survive (Desai, 1998). Guarding still has significant utility as a crop protection tool and is also very important as a way to augment other crop protection schemes.

► Operating principle:

Guarding systems work on the principle of fear; in this case elephants' fear of humans. Elephants, like most animals, have learned over time to fear man as a predator and hence generally avoid humans and human use areas. The extensive killing and capture of elephants in the past would have built this fear in all populations living near human habitations where capture and killings took place. Hence the very presence of humans guarding crops acts as a deterrent. This fear can be witnessed even in PAs in Asia where elephants will run or move away once they detect

humans (tourists). It is best seen in east Africa where elephants are particularly afraid of Maasai men (who used to spear them), and even the sight of their clothes, scent, and voices trigger alarm in elephant herds (McComb et al., 2014). Other than human presence itself, which is the primary deterrent, all other guarding activities mainly function towards either announcing human presence or to reinforce the predator-prey relationship. Noise making, from shouting to the use of noise making devices, basically announce human presence. Similarly the use of light, be it fire or flashlight, serves the same function as noise. In this context fire implies a fixed fire source and not fire based projectiles. The use of projectiles essentially reinforces the predator-prey relationship by exposing the elephants to physical attack. Projectiles vary from seriously harmful to those that cause minor pain and are mainly harmless. Essentially all these tools simulate a predator attack on the elephants and reinforce the predator-prey relationship.

The principle on which guarding is based will deteriorate or fail under three conditions:

1. When the 'predator' component (announced human presence) is not present or visible at the crop field, i.e. no guarding or sleeping instead of guarding. Open human use areas and human scent still act as deterrents but for only a limited time, and eventually elephants realize that there are no humans (which they can detect) around. Hence they will be tempted to enter the crop fields. This could lead to some elephants becoming habitual crop raiders as they will keep testing fields for guarding, and eventually learn that harmless guarding methods do not cause them any real damage.

2. Guarding will fail when elephants get habituated to the noise and light used to scare them and realize that these are harmless. Some even tolerate gunshots (usually small pellets, but often bullets) fired at them and become habituated to crop raiding.

3. Guarding will fail when the predator-prey relationship breaks down in the sustained absence of reinforcement of this relationship; in this situation elephants gradually learn that humans are no longer harmful to them and stop fearing them. The time needed for such a change will vary depending on the behavioural characteristics of individual male elephants and herds.

Wild elephants cross a public road. *Photo by Elephants on the Line*

Essentially there is a need to sustain effective guarding to ensure that elephants do not learn to intrude into human use areas. Guarding should also involve regular changes in guarding tools so that elephants do not become habituated. The failure of communities to understand the behavioral context of these requirements has resulted in the gradual erosion of the effectiveness of guarding as a primary tool. This is particularly true of communities that have occupied recently cleared elephant habitat to practice agriculture. In such situations people do not know how to implement guarding in the best possible way, and the elephant population has stabilized and contains a significant number of obligatory crop raiders because of the habitat loss. This combination contributes to a failure of guarding as a crop protection tool in most instances. It also results in increasing conflict as time goes by, unless retaliatory killing or harmful tools are employed in guarding.

► Situations where guarding is applicable:

Guarding as a standalone crop protection tool

Guarding as the main crop protection measure works very well in areas where the interface between human use area and elephant habitat has been established a long time ago. In such situations, elephant ranging would be largely confined to forest areas due to past capture, killing, or natural death of those elephants that originally ranged in areas currently used by humans. The removal of elephants involved in conflict brings about some stability to the interface area, and the interface acts as a real boundary or psychological barrier that is not normally crossed. Any residual elephant movement or new movement into cultivated areas for crop raiding is then effectively controlled by well implemented guarding efforts. Essentially guarding will work very well in low conflict areas, but it will also contribute to significant reduction of conflict in medium and high conflict areas. When used as a standalone method in medium and high conflict areas, guarding helps minimize conflict by stopping opportunistic crop raiders. It also minimizes opportunities for elephants to become habitual crop raiders by not allowing free access to crops. However it will not stop obligatory and existing habitual crop raiders from raiding crops.

Guarding in combination with other crop protection tools

Typically in medium to high conflict situations, guarding should be used to augment other crop protection tools such as electric fences, other non-physical barriers, elephant drives, etc. In all these cases it will significantly improve the overall deterrent effect. When used in combination with electric fences and well implemented, it can even stop obligatory crop raiders. However, in very high conflict areas and in situations where there may not be adequate commitment towards crop protection or other vested interests are at play (corruption resulting in poor implementation), such a double tool strategy may not work. For example, in Sri Lanka in the Handapangala area, large company owned sugarcane fields are protected by electric fences and a complex guarding system that involves vehicle based mobile patrolling of the perimeter and fixed guard stations at vulnerable points, and yet some elephants break through almost every night (Desai, 1995). It is obvious that the fence does not act as a real barrier as it is pushed down regularly by elephants that are habituated to breaking it. Therefore getting past guarding posts and patrols is the only real problem the elephants have. Mobile patrols can easily be avoided by waiting until they pass before elephants enter the crop fields. Guard posts may be crossed when people fall asleep or if the elephants are habituated to noise and other scaring devices used; then the guard posts will not be effective. The question of commitment of the guards who are paid employees and not owners is also an issue. It is also possible that there are too many habitual and obligatory crop raiders and, as such, both electric fences and guarding are not the best tools for the type of HEC that is prevalent in this specific area. Alternatively, the slow build-up of crop protection devices with initial poor

implementation would have allowed elephants to get habituated to, and consequently overcome various techniques and tools used in crop protection. Hence it is critical to implement crop protection strategies effectively from the start and not allow elephants to learn at the outset how to overcome these crop protection tools.

► Primary change in guarding between the past and present:

In the past (referring to 100-150 years ago) there were three main factors that contributed to the success of guarding. First was the option of lethal removal of elephants in and around areas developed for agriculture. This significantly reduced the number of obligatory crop raiders and brought stability to the interface area which now became a no-go area for elephants to a large extent. This is seen from the few but very informative reports from Sri Lanka in the late 1800's and early 1900's period. In the Northern Province of Sri Lanka, bounty was paid for the killing of 3500 elephants in three years prior to 1848 (Olivier, 1978). Similarly, between Galle and Hambantota, bounty was paid for the killing of 2000 elephants between 1851 and 1856 (Olivier, 1978). Second, such actions reinforced the predator-prey relationship, and, lastly, when guarding started to fail and crop depredations became a serious problem, elephants were once again removed as seen from this record from Kodagu in southern India: "In 1822, the ryots complained to the then Rajah about the great destruction of their crop fields and houses caused by numerous herds of elephants. The Rajah took a decision to resolve this problem by destroying elephants. There were 233 elephants killed with his own hand within 38 days whereas his soldiers caught 181 alive" (Richter, 1870). Such interventions certainly reduced the number of crop raiding elephants and also reinforced the predator-prey relationship, making guarding a usable crop protection tool. This change, coupled with increased habitat loss, degradation, and fragmentation which brings greater number of elephants into conflict with people, requires improvement in guarding techniques where guarding remains an option and where it is used to augment other crop protection measures.

► Types of guarding:

Guarding poses several challenges to those implementing it, and hence variations in guarding have evolved to meet those challenges. Often compromises have to be made which result in reduced effectiveness. In a general sense, guarding is done from a fixed point, usually from a location which offers safety and visibility, or by patrolling either around the perimeter of the crop field, or at the boundary of elephant and human use areas.

Guarding from a **fixed point** is best suited for small individually guarded crop fields with good visibility; it is also suited for larger areas which have visibility along the perimeter. In the latter case it is possible where there is cooperative community guarding or where company owned farms are guarded by company staff. Guarding stations can be protected or unprotected; protected stations involve some type of barrier such as elephant proof trenches around the guarding hut, or involve platforms on tall trees located in or near crop fields.

Where visibility (detection distance) is poor, **patrolling** the perimeter is better suited. Patrolling can be done on foot, or using vehicles where farms are very large. However, patrolling as the only crop protection measure has limitations in larger areas as elephants learn to enter the crop field when the patrolling team has moved past them. Patrolling therefore needs to be combined with fixed point guarding stations to make it effective. Patrolling is best suited when guarding is used to augment other crop protection tools such as electric fences. Patrolling is used when more people are available and is generally not used by individual farmers.

Preparing for night guarding on the boundary of Way Kambas National Park, Sumatra. *Photo by Nazaruddin*

Patrolling on elephant back is also used as a guarding strategy; the main difference is that this is a daytime activity whereby the patrols attempt to locate wild elephant herds that may be moving towards crop land. Elephant back patrol teams will then drive the elephants away before they can reach the agricultural areas. Patrolling on elephant back to address HEC is practiced in several range countries in Asia (Riddle, 2007). While on patrol the trained elephants provide transportation for staff, and can drive away crop raiding wild elephants should conflicts arise. They may also be used as a tool to gain the interest of local communities during awareness events. To operate effectively elephant back patrol teams require proper training, both of the elephants and of the elephant handlers (mahouts). Trained elephants used to chase wild herds away from agricultural areas need to be selected based on individual personality; they should not be fearful of the wild elephants. The elephant back patrol teams should also be trained to develop their own capacity to evaluate HEC mitigation options in their specific working area, this includes collecting field based assessments of various aspects of the conflict.

► Implementing effective guarding:

Assessing suitability and requirements

Planning a guarding strategy for crop protection requires understanding the type of crop raiding that is occurring in the specific area. Currently, given the large scale loss and fragmentation of elephant habitat, most human use - elephant habitat interface areas face all types of crop raiding i.e. opportunistic, obligatory, and habitual raiders *(See Section 2)*. However there are still some areas where habitat loss has not been significant, or elephant densities are low, or small settlements exist inside good habitat, where guarding can be used as the main crop protection tool. However, in most areas, guarding should be used to augment other crop protection measures. Where other crop protection measures are not available, guarding should be used as it will stop opportunistic crop raiders and also minimize the chances of elephants becoming habitual raiders. Hence, guarding as a crop protection tool is important in all areas with HEC.

Once guarding has been selected as the primary crop protection tool, or as a means to augment other crop protection tools, the first step is to decide on the method of guarding, either from fixed points or by patrolling. Guarding from a fixed point would be the safest for individual farms where cooperative guarding is not practiced. This ensures safety to the farmer as patrolling singly or by just two people would be dangerous in areas where elephants are aggressive. Where cooperative community based guarding is possible, or with big farms, guarding from multiple fixed points and patrolling are both suitable. However, depending on visibility, multiple fixed points are likely to be more effective than patrolling; there is always the possibility of elephants entering the crops after the patrol has passed them. This is true even when guarding is used to augment other crop protection methods such as electric fences.

Implementing a guarding strategy

The location of fixed guarding site(s) should be based on the size of the crop field, visibility, and number of people available for guarding. In addition to visibility, the guarding point should also take into consideration sound, as much of the detection of the elephants can be based on sound. So the location of the guarding point should be such that there is a good chance of hearing elephants entering/feeding on the periphery of the crop fields. Site selection should also take into account the location of potential paths available to elephants to reach the crop field. In more open habitat there will be a higher number of paths, but in denser habitat they will be less. The selection of guarding points should be optimized to detect elephants coming from different paths. Identifying such paths is also important for patrolling, as the patrolling team needs to be aware of where elephants are likely to come from. Even when designing advance warning systems such as a tripwire alarm extra emphasis needs to be given to such paths. Additionally there is a need to recognize that elephants are capable of creating new paths when access through old paths is blocked. When patrolling is used as a guarding strategy, a path should be cleared around or near the perimeter of the agricultural area so that there is good visibility and the patrol team does not get surprised by elephants at dangerously close distances.

The key to guarding is being able to drive elephants away with confidence; hence a safe guarding point is critical. However, wooden watchtowers constructed along the edge of the crop field have also been used as observation and guard posts in Sumatra (Hedges & Gunaryadi, 2010) where elephants are less aggressive than in South Asia. Such towers may be unsuitable for areas where elephants are aggressive, for example in south India. In West Bengal (India) very stout towers made of tree trunks are used for such watchtowers. Safety features depend on the aggressiveness of the elephants involved. In areas with aggressive elephants, unsafe guarding sites (especially on trees or platforms) can be indicators of either poor guarding efforts or of guards using lethal or very harmful methods to drive away elephants. In the former case they will avoid antagonizing aggressive elephants, and in the latter case they are not afraid as their actions will drive away even aggressive elephants.

Guarding small fields can be done by a single person; normally individual farm owners and their family members do the guarding. This requires significant effort by an individual or his family as the same person also has to attend to daytime work. Where larger farms are involved, there is a need to have two or more guard stations or patrolling teams and this requires greater manpower. In many areas people organize themselves into groups and practice cooperative crop protection. For obvious reasons, cooperative crop protection is much more effective at reducing HEC than individual efforts. There is less effort required individually, and more people are effectively involved in guarding. The efforts are also more systematic and more elaborate as pooled resources ensure that more and better resources are available at the periphery of crop fields where needed, rather than at the centre. Cooperative guarding also allows members to rotate duty so that they spend fewer nights guarding, thus helping to minimize sleep deprivation. In addition, cooperative guarding also ensures that a well-organized and committed team is available for other crop protection activities such as driving elephants (during the day) away from

their village area, as well as implementing and maintaining other crop protection tools (i.e. electric fencing). Cooperative guarding systems are far superior to individually managed crop protection methods and should be encouraged.

Another form of guarding is related to elephants' preference of some crops at a certain stage of growth. For example, in South India elephants prefer to feed on paddy and finger millet (ragi) when these crop mature (seed set) until they are harvested. In Mudumalai Tiger Reserve in south India, guarding paddy fields was largely confined to this period and the fields were left unprotected in the growing stage. Low intensity guarding was practiced to stop deer from feeding on the crops during the growing stage as it is much easier to protect crops from deer. Intense guarding was initiated when the crops started to mature, and tripwire alarms were also used to assist in detecting elephants and wild pigs (Balasubramanian et al., 1995).

Challenges of guarding strategies

The challenges to organizing community based guarding stem from social divide within communities, which is why it is not so widely practiced. It can be as simple as no one taking the initiative to start community guarding. Often it is based on more complex and serious issues related to social division in the community based on caste, religion, socio-economic status, political affiliations, location of crop fields, etc. These issues minimize cooperation or collective action between social divisions. The last category, location of crop fields, is very difficult to surmount and is present even in classless societies. Basically crop raiding is more intense at the periphery of agricultural areas which abut elephant habitat, and less intense or absent in the central part of the agricultural area. This is generally true for most agricultural areas except for very small agricultural areas where there is hardly any distinction between periphery and interior areas as they can be only a few crop fields wide, and hence crop fields are all equally exposed to raiding. Cooperative community based guarding requires initial efforts by way of awareness and capacity building, initiating positive dialogue between groups with different socio-political affiliations to resolve divisive issues for the benefit of all individuals and of the community as a whole. Community based cooperative guarding can be most easily implemented in homogenous societies. In Sri Lanka, where irrigation water and fertilizer distribution are managed by the government, it is easier to get cooperation and contribution from all people in the community through such departments. Other considerations can also play a role in the effectiveness of cooperative community based guarding. For example, in Sri Lanka the Department of Wildlife Conservation organizes community groups to protect their crops and issues thunder flashes, which are very effective firecracker based scaring devices. But officials have become wary of this scheme as they fear that the gunpowder in these thunder flashes is being used to charge 'trap-guns' set to kill deer and pig for meat, and also to injure crop raiding elephants (Desai, 1998). The community groups to which thunder flashes are given are themselves often unfair in their distribution and use, which benefits only a select few (Desai, 1998). Such misuse of support can bring about reduced cooperation and make community based crop protection less effective.

Where elephants are aggressive, the safety of those people who are guarding is also a critical consideration. In the case of guarding from a fixed site, the site should either have a platform on a suitable large tree, or it should have an elephant proof trench around it. In the absence of these precautions, guarding will be ineffective as people will tend to either keep quiet or run away when faced with aggressive elephants (Desai, 1998). Selection of trees for platforms depends on the species, girth, and height. Some tree species are deeper rooted and hence more difficult for elephants to push down. Girth depends on species, as some break easily while others have harder wood. Normally the platform should be fixed at a height of at least ~7 meters (~21 feet), and at the lower level, a minimum height of ~5 meters (~15 feet) is necessary with the added ability to

easily climb higher should an elephant make a move to reach into the platform. Usually male elephants are the ones who will try to attack people on platforms, and their reach can be more than 5 meters. As a precaution, chilli powder can be kept on the platform to sprinkle down if an elephant tries to reach up or tries to push the tree down. Such cases are rare, but attacks have been known to occur and the response is generally to stop driving activities from the tree platform when the elephant approaches an unsafe platform. The same is true for ground based guarding sites; unsafe sites are easily abandoned when aggressive elephants start approaching them (Desai, 1998). Farmers guarding from unsafe sites often state that when they shine flashlights to look at elephants and drive them away, the aggressive elephants come straight towards the light source so they have to turn off the flashlights or abandon the guarding site. In cases of guarding sites located on the ground, an elephant proof trench with a dimension of 2.5 - 3 meters (8.1 - 10 feet) and a depth of 1.8 - 2.1 meters (6 - 7 feet) deep should be dug. In ground guarding sites it is also important to keep a fire burning or have the ability to start a fire quickly to dissuade any elephants from trying to cross the trench.

Sleep deprivation results in poor guarding as those people who are guarding tend to fall asleep. Sleep deprivation also results in health problems due to stress, and deprives a farmer of normal social and family life. In areas with low elephant densities or where crop raiding is very infrequent or unpredictable, guarding can become slack during periods when there is no raiding. When coupled with sleep deprivation it results in farmers opting for reactive guarding. In reactive guarding people do not guard crops until elephants are noticed in the vicinity of their village, or they sleep while guarding and hope to be woken up by the noise made by elephants raiding crops. Usually elephants make noise only when they are feeding on certain crops such as sugarcane, banana, oil palm, rubber, etc. and with such crops visibility is often poor, hence guards depend on noise to detect the elephants. However there is always some crop damage when using this method. The other method is proactive guarding where the guard stays awake all night to guard the crops. In proactive guarding the efforts are directed towards stopping elephants from entering the crop fields. Even when implementing proactive guarding poor visibility due to the perimeter structure or due to the crops grown results in detection being limited to sound; however as the guards are awake they will detect sound faster than guards who are sleeping.

To overcome both sleep deprivation and poor detection, people have resorted to early warning systems. The most commonly used early warning mechanisms involve tripwire triggered firecrackers (usually a homemade explosive). A wire or rope is strung around the perimeter of the crop field abutting the forest and at regular intervals the wire is attached to a firecracker (small explosive) or an electric alarm. When an animal pushes the wire it sets off the explosive or alarm thereby alerting the guards who drive the elephants away before they enter the crop field.

► Deterrent tools to complement guarding:

Detection of the crop raiding elephants remains a major issue for guarding, especially with larger farms as elephants generally raid at night. Detection is mainly based on moonlight and on nights when there is less or no moonlight the use of an artificial light source such as flashlights helps. Elephants seem to prefer to raid when there is less moonlight (Barnes, 2013) and during monsoon when most of the crops are grown and cloud cover blocks out most of the moonlight. Flashlights using incandescent bulbs are the most commonly used light source, even though their coverage is limited and the cost of batteries adds to the economic burden of crop protection. Currently available flashlights using LED are much more energy efficient, brighter, have a longer throw than those with incandescent bulbs, and are best suited for guarding. While flashlights significantly help in detection they are not very useful when visibility is poor (tree crops, sugarcane, etc.). Flashlights are a ‘must have’ tool when patrolling is used in guarding. When artificial light sources (flashlights) are not available, sound is the only way to detect elephants entering

Elephant herd in tea estate, Assam, India. *Photo by Elephants on the Line*

crop fields on dark nights. This method is not very effective if feeding does not result in detectable noise.

A major tactical advantage was gained with the development of the tripwire alarm, which made it possible to detect elephants approaching crop fields. Tripwire triggered alarms probably evolved as a mechanism to detect wild pigs which are far more difficult to detect even when they are actually feeding in the crop field. In many areas the height at which the tripwire is placed indicates that wild pigs are the primary targets. Tripwire alarms significantly improve detection and achieve improved deterrence as elephants are stopped before they actually enter and damage crops. Tripwire alarms also significantly reduce the need to stay awake at night as the guards can wake up when the alarm is set off and then drive the elephants away (Balasubramanian et al., 1995). Tripwire alarms are also useful where guarding is used to augment other crop protection tools (electric fences, drives, etc.) (Fernando et al., 2008)

The basic construction of a tripwire alarm using a cable/wire that triggers an alarm is the easiest and most cost-effective to implement. However, the alarm itself can be changed from an explosive (firecracker) to an electric bell or equivalent noise making device. While this may add more cost to the system, with increasing regulations and restrictions on gunpowder and crackers the use of electric sound making devices may be the best way forward. At present makeshift devices are used, and waterproof devices with better housing need to be developed. More recently electronic detectors like IR motion detectors and even seismic detectors (Wood et al., 2005) that can sense elephants and trigger the alarm are being discussed and tested. However, in any remote triggering system the costs, advantages, and ability to maintain them in the field are critical. The wire based tripping mechanism offers far greater advantages in terms of costs and maintenance, and unless something cheaper and easier to maintain is found it would remain the best tool for the task. IR motion detectors can at best detect movement up to 20 meters away, which would translate into at least 5 sensors for 100 meters, which is the length a single tripwire system can cover. Even if the costs of IR motion detectors were reduced to less than that of the wire used to trigger the alarm,

the costs will still be high as a number of alarm devices would be needed due to the limited detection range. Additionally, visibility would pose serious problems for IR sensors as they cannot be placed in dense vegetation outside the crop fields to act as early warning systems. Tripwire based alarms could be deployed inside the forest to give early warning, as visibility is not a problem for this system.

Tripwire alarms are suitable for guarding small and large farms or longer agriculture-elephant habitat perimeter. As the distance between alarms needs to be reasonably short so that the guards know from where the elephants are approaching the crop fields, the system functions with numerous sub-units located at fixed distances all along the perimeter. Ideally the tripwire should be around 50 meters on either side of the alarm, and this would cover a 100 meter section of the perimeter. It is fairly easy for guards to locate the elephant(s) within this short section after the alarm has been set off. Tripwire alarms are targeted more towards wild pigs which also cause considerable damage, but when targeting wild pigs the tripwire is set low and hence elephants can step over it. To target both elephants and wild pigs a double tripwire system needs to be implemented, with one wire at the lower level (30 - 50 cm above ground), and another at a greater height (~150 cm). Both these wires can be attached to and trigger the same alarm, so the cost increase will only be for the additional wire. This will ensure that both wild pigs and elephants are specifically targeted by the tripwire alarm.

Once elephants are detected they are driven out of the crops by various methods, some of which are discussed here:

1. NOISE

a. Shouting, beating drums and tins, use of hollow split bamboo, firecrackers, etc. are some of the noise making methods used to drive elephants out of crops. Of these, **firecrackers** can be the most effective, especially things like rockets which explode at the end of their flight. In Sri Lanka there is a special device called the 'thunder flash' which is a tube with a fuse stuck to its side that can be ignited with the sulphur strip on the side of a matchbox. The person using it holds the tube facing the elephants. When ignited it causes a small explosion within the tube and a second charge is then shot from the tube towards the elephants. This second charge acts like a rocket leaving behind a fiery trail and smoke as it travels towards the elephants. The second charge then explodes with a loud bang near the elephants. Elephants see the fiery trail and smoke heading towards them before the second explosion; this scares them a lot more than an ordinary cracker. In Sumatra (Indonesia) a carbide gun is used; this is basically a plastic or tin tube with a small container at one end into which carbide and water are placed to generate methane gas in the tube. This is then ignited through a small opening at the top of the rear end and the methane explodes with a loud bang.

b. **Noise making devices** located at remote locations are often used by farmers when guarding from tree platforms. Tins or other metal objects are tied to poles, trees or small platforms at different points in the crop field. A stone or metal object is attached to a rope and hangs next to the tin. A rope from the main guarding platform is attached to the stone, when it is pulled and released the stone strikes the tin making noise. When several such devices are placed at different locations, the noise from them confuses elephants as they hear sound from different directions but cannot see or detect humans. This approach to scaring works every well as it adds confusion in addition to fear. These devices are fairly simple, easy to set up, and very inexpensive as only the cost of string or rope is involved. Currently, electronic devices which incorporate IR motion detection triggered playback of pre-recorded sounds or sounds from a radio-station are used to scare deer. Similar devices which trigger lights are also used to scare deer and carnivores. However the cost-effectiveness of using such devices for elephants is not known and detection distances remain short. They may, however, be useful for protecting high value resources like haystacks, stored grain, etc. but effectiveness will remain a problem with light based devices. Additionally, aggressive elephants may not hesitate to approach the sound making devices. The traditional remote noise making devices remain very useful tools for guarding and there is a possibility

of adapting them to patrolling purposes also. If patrolling teams can confuse elephants by making noise from multiple devices along the perimeter while remaining in a safe location then it may be easier to drive elephants away. Some farmers also use noise as a tool to continuously make elephants aware of their presence. In this approach farmers continue to shout or beat drums at regular intervals to let elephants know that they are watching over the crops. Patrolling teams also shout, beat drums, or use other noise making devices to warn elephants of their presence. As elephants tend to get habituated to noise it is not clear how well this approach works but it is very likely to deter opportunistic crop raiders when they are aware of human presence. However with obligatory or habitual crop raider this method may not work and in fact might habituate them to the noise.

2. PROJECTILES THAT CAUSE PAIN

a. **Harmful projectiles** such as spears and arrows are used in some areas, although their use is illegal. Sometimes the arrowhead has a long metal shaft and this allows the head to be kept in a burning fire. The hot arrow is shot at elephants that are raiding crops. Guns, usually muzzle loaders, are also used to shoot at crop raiding elephants. The charge is usually small pellets, but small metal balls or bits of rods are also used and are dangerous as they can cause fatal injuries; as the elephant's death is not instantaneous the perpetrator goes free. In areas of high conflict, burning substances (rubber tires, oil soaked cloth) are also used as projectiles in rare cases. These methods, although illegal, do reinforce the predator-prey relationship. However some elephants will continue to raid crops even when they are seriously injured by gunshots. In high conflict areas it is common to see habitual crop raiders with gunshot injuries.

b. The use of **stones** either thrown by hand or using a catapult is much less harmful and causes only pain without serious injury to the elephants. The use of a catapult allows the guard to operate from a greater distance and thus improves personal safety. This method is generally far more successful than just making sound as it too reinforces the predator-prey relationship between humans and elephants.

3. ODOURS

a. The use of acrid smell, for example **chilli smoke**, has been tested in Africa (Osborn & Rasmussen, 1995) and Asia (Baishiya et al., 2012) and reported as being successful to deter elephants from raiding crops. However it has limitations as both the agriculture-elephant habitat perimeter and the direction from which the elephants approach can be different from that of the wind. If the wind is in the wrong direction, the smoke would not affect the raiding elephants but may cause problems for the villagers. For this tool to work the elephants need to be downwind of the agricultural area. Studies of odours as deterrents have assessed the use of novel smells such as compounds from the secretions of bulls in musth, tiger urine, even decaying castor fruit, but results are inconclusive.

4. FIRE

a. Fire has also been used largely to deter elephants from approaching crop fields; however this is of limited use as elephants can generally circumvent the fire. Light from handheld burning torches is also used to drive elephants out of crop fields, but it is not very effective against habitual raiders or aggressive elephants.

Key Considerations
Guarding

- Guarding is the most common and widely practiced crop protection method in all Asian elephant range countries.
- The very presence of humans guarding crops acts as a deterrent.
- Guarding should involve regular changes in guarding tools so that elephants do not become habituated.
- Guarding should be used to augment other crop protection tools.
- Planning a guarding strategy for crop protection requires understanding the type of crop raiding that is occurring in the specific area.
- Detection of crop raiding elephants remains a major issue for guarding as elephants generally raid at night.

Elephant patrol unit driving crop raiders back to Way Kambas National Park, Sumatra. *Photo by Nazaruddin*

Barriers and Deterrents

► Origin and current application in HEC mitigation:

Barriers and deterrents either act as obstacles that stop elephants from entering crop fields or act as warning signals that dissuade elephants from approaching or entering crop fields. Barriers such as bamboo fences, thorn fences, hedgerows, etc. possibly evolved as crop protection tools primarily aimed at herbivores other than elephants. For such herbivores these simple barriers act as physical barriers. But such simple barriers are incapable of functioning as physical barriers to stop elephants. Elephants can easily break through such simple barriers as they do not pose a physical challenge to them. In and around most, if not all, elephant habitats, elephants are not the only crop raiders. Many other herbivores such as wild pig, deer, wild bovids, and antelopes also raid crops and simple barriers mainly target these other species and not elephants. But even simple barriers function as psychological barriers as breaching them implies entering into human use areas. Barriers have evolved over time, and barriers capable of stopping elephants have also been developed. Among the most widely used barriers for elephants are electric fences (EF) and elephant proof trenches (EPT). Numerous other types of barriers are being used or tested for crop protection against elephants and other herbivores but results are still inconclusive.

► Operating principle:

There are two basic principles on which barriers work: the first is psychological and relates to either the inherent fear of humans which elephants have or the fear of a novel object or sensation. The second principle is physical, where the barrier is physically capable of stopping an elephant from crossing it.

In the first case the barrier, irrespective of its type, signals or reemphasizes the presence of humans and also makes the elephant clearly aware that it is entering a human use area. It also poses a physical challenge, ranging from mild to moderately difficult, for the elephant to breach. Most barriers used earlier were primarily employed to stop herbivores, other than elephants, from entering crop fields; those barriers pose a far greater physical challenge to these types of animals. Where such barriers are used, guarding is almost always used as the primary tool against crop raiding, as human presence acts as the primary deterrent. Elephants (and other herbivores) have to first overcome their fear of humans, and then they need to break through an obstruction made by humans to reach the crops. Irrespective of their type, barriers make guarding more effective. Where fear of humans is the primary deterrent, the barriers are largely psychological barriers. **Psychological barriers** include bamboo/wooden fences, thorn fences, barbed wire fences, chain-link/wire mesh fences, chilli rope fences, most bio-fences, minor rubble walls, and EFs. All of these are based on the inherent fear that elephants have of humans and of causing discomfort or a mild physical challenge to elephants attempting to enter crop fields. It is very important to remember that psychological barriers are tools that enhance guarding and as such they cannot be used as a standalone crop protection tool. In addition to barriers, deterrents that trigger visual, sound, and odor based warnings in elephants are also being tested or recommended. These too work on the principle of psychological fear of humans or other natural threats that elephants face in their habitat. Most of these which are suggested as possible solutions to mitigate HEC are still largely experimental. These deterrents include light and sound which trigger the fear of humans, large predator calls, elephant alarm calls, bee hives, and musth odour which can trigger alarm

in elephants. Other novel odours such as decaying castor fruits have also been suggested as possible deterrents.

The second operating principle is based on physically stopping elephant from crossing into agricultural areas. **Physical barriers** can be used as standalone crop protection tools. As mentioned earlier, most barriers used to stop other herbivores do not pose much of a challenge to elephants. Therefore elephant specific barriers such as EPTs, walls, steel cable and iron post fences, etc. which are supposed to be impossible for elephants to cross have been developed. Such barriers are primarily based on the principle of insurmountable physical obstruction; hence there is no need for additional support like guarding. If well designed and constructed, such barriers are true standalone solutions to HEC. Physical barriers most commonly used are EPTs, but steel rail/cable fences (i.e. the fence in Addo NP in South Africa) or strong walls can also as act as physical barriers that prevent elephants from crossing into agriculture.

► Types of barriers:

Bio-fences

Bio-fences or hedges are made of thorny plants or plants with irritating secretions which animals avoid. Most bio-fences target domestic cattle and other herbivores and are ineffective against elephants as they can easily push through such fences. Another problem is the difficulty in growing bio-fences as continuous and sufficiently wide barriers along the edge of crops fields. Gaps are invariably created during the planting/growing stage by elephants and other herbivores that break through and trample the hedge. Such gaps are usually blocked using thorn branches or bamboo/wooden barriers which are effective against other herbivores but not against elephants. Bio-fences currently used are applied at the individual field level by individual farmers. With adjoining farmers adopting the same strategy, sections of a village perimeter can be protected by a common bio-fence. However, at present, there are no bio-fences that enclose a village or a large section of agricultural areas outside forests. Bio-fences, with the exception of Palmyra palm trees, are largely psychological barriers which possibly include a minor irritant or physical challenge value. Although their primary function is to stop other herbivores they can bring some added elephant deterrence value when guarding is used as the primary crop protection tool. However care needs to be taken to ensure that bio-fences do not obstruct visibility causing reduced guarding efficiency.

Agave has been suggested as being suitable for bio-fencing against elephants (Perera, 2009; Metha, 2012). Agave has a single main spine at the tip of its leaves and it is hoped this would act as a deterrent. However, elephants use their trunks and feet to push aside shrubs in their path and thus are able to push aside the agave leaves (and thorn) without getting injured. It appears that using agave as a bio-fence may not be practical or feasible; attempts at growing this barrier have failed so far (Fernando et al., 2008). Trees belonging to the **Citrus** genus (lime, orange, sweet-lime, etc.) have been suggested as possible bio-fences to stop elephants and are based on the assumption that elephants do not feed on these plants and some of these trees have strong thorns. But these types of trees may not be suitable as bio-fences as elephant are used to thorny trees and shrubs in their natural habitat and are unlikely to be stopped by such trees. Furthermore elephants are known to eat citrus. In Hassan District in southern India, oranges that are randomly grown inside coffee estates are eaten by elephants. These orange trees are not grown as a crop, and hence elephants occasionally feeding on these fruits are not seen as crop raiding.

More recently there have been attempts to test **Palmyra** palms or toddy palms (*Borassus flabellifer*) trees planted in several rows (1.5 meters between trees and 2.4 meters between rows) as bio-fences (IEF, 2013; BBC News, 2014). There are numerous challenges that need to be resolved to raise such bio-

Agave plants damaged by elephants. *Photo by Heidi S. Riddle*

fences. Given the long germination and growth period of the palms this bio-fence is best tested at one large site in a comprehensive manner rather than in multiple smaller sites where other confounding factors may mask its success or failure. Experimental testing of this bio-fence at one or two villages may result in deflecting elephants to other un-protected villages. Its effectiveness as a potential HEC tool will be better understood when it is implemented on a larger scale so the deflection of elephants does not give false positive results. It is still not known how elephants will react to this bio-fence if access to all crops is lost, and whether they will push down these trees or if the trees would be able to stop elephants. Space for this type of bio-fence would be a constraint; it would have to be planted on the forest side as farmers would not allow four rows of palm to be grown on their land thereby losing an approximately 12 meter wide strip of land. Initial trials using seeds to grow Palmyra have shown very poor results with only 10-15% regeneration, but this can potentially be overcome by raising seedlings in a nursery. The palm seedlings need to be protected from elephants and cattle for 4 to 8 years with an electric fence until the bio-fence becomes an effective barrier (IEF, 2013).

The costs of establishing a Palmyra bio-fence, with a possible need to replant gaps due to poor growth or damaged trees, and the costs of establishing and maintaining an electric fence for 8 years need to be weighed against the long term benefits provided by a Palmyra bio-fence. The feasibility and practicality of implementing such a strategy at the landscape level needs to be taken into consideration. With an estimated requirement of 2500 trees/kilometer of boundary, the likelihood of raising adequate seedlings and nurturing them for 4-8 years to fence hundreds of kilometers of boundary needs to be evaluated. This type of bio-fence would require suitable barriers at all entry and exits points of roads and paths used by people and cattle, otherwise elephants will use these points to enter agricultural areas. An electric fence or any other barrier that can successfully stop elephants for 4 to 8 years can be assumed to be effective over much longer periods, which then questions the need for a bio-fence. The advantage of a Palmyra bio-fence is that it has the potential to continue functioning as a standalone barrier for nearly 80 years without major maintenance or guarding costs. On the other hand an EF or EPT require costly maintenance, and, in the case of EF, the additional costs of guarding over such an extended period.

Minor Physical Barriers

Minor physical barriers such as fences made of bamboo, wood, wooden planks, thorn branches, barbed wire, chain-link or wire-mesh fences, etc. are primarily targeted at herbivores other than elephants. Such fences pose only a minor physical challenge for elephants to breach them. However, they function as an extra psychological barrier when guarding is also used as a primary crop protection tool against elephants. It is important to recognize the correct function of these fences which is to stop domestic cattle and other wild herbivores, and not discount their function in crop protection. But they cannot be used as primary barriers for stopping elephants from raiding crops. In an effort to improve their visibility to elephants and other herbivores and enhance their impact, farmers often add alterations to these fences which increase the psychological deterrence effect. Shiny objects such as metal foil strips, old CD disks, white cloth, etc. (Chelliah et al., 2010) or minor sound making devices such as pairs of glass bottles or metal objects which clink against each other whenever wind moves them, or lamps which rotate based on wind direction are strung or placed along fences (Fernando et al., 2008). These add-ons make fences more visible to elephants and add value to the deterrence effect.

As the primary objective of such barriers is to stop domestic cattle and other herbivores, the utility and added extra psychological deterrence value they bring to guarding for HEC cannot be ignored. The cost of construction and maintenance of such barriers is minimal and involves mainly labor during the initial construction. In the absence of other better crop protection tools, such barriers are useful as supplemental crop protection tools when guarding is the only method available to farmers.

Solid Physical Barriers

Solid physical barriers to prevent HEC generally consist of metal or rail fences or walls (stone, cement, brick, etc.). These types of barriers can be very expensive if they are built properly to stop elephants; they can be used in special situations or to overcome weak spots in other systems. Due to the high cost of construction, solid barriers for HEC are generally used only on a small scale. However, they can also be used to supplement other barriers such as EFs, for example in areas where elephants may often try to breach an EF.

Chilli-Grease Fences

Osborn and Rasmussen (1995) first tested the effect on elephants of oleoresin capsicum (10% concentration) sprayed from an aerosol can and found that it repelled elephants. Osborn (2002) later reported that it was more efficient than traditional methods such as noise to drive elephants away. However, being an airborne repellent it can be used only if elephants are downwind and this severely restricts its utility in the field. More recent experiments have focused on using chilli-grease fences as crop protection barriers against elephants (Osborn, 2002; Govindaraj et al., 2007; Mehta, 2012). Chilli fences are based on the assumption and principle that elephants find hot (spicy) chillies noxious and that both the smell and touch are irritants. A chilli fence consists of a rope (or two ropes) set at a height of 1.5 to 2 meters, the rope is coated with a mixture of chilli powder or ground chillis and waste grease or engine oil. The use of the hottest chillis (highest capsaicin content/highest Scoville heat units) available locally is recommended for effectiveness as well as availability. The mixture of chilli and waste grease/oil (e.g. 1kg of chilli powder mixed in 1 kg oil or grease) or sometimes chilli powder, tobacco, and waste grease/oil (e.g. 1kg chilli powder plus 1kg tobacco mixed in 10 liters oil or grease) is used to coat the rope. Repeat application are done ranging from daily to once every 3 days and a need for more frequent applications is suggested in areas with higher rainfall. The deterrent value of tobacco has not been specifically evaluated for elephants.

Currently chilli fences are largely experimental and there are conflicting reports about their success. Chelliah et al. (2010) report that experiments with chilli fences indicated that success was dependent on rainfall. Their study of three villages of differing rainfall (high = 4.9 mm/day; medium = 2.8 mm/day

and low = 0.6 mm/day) indicated that 27%, 50%, and 79% of the elephants that approached the fence (within 25 meters) in the high, medium, and low rainfall areas were deterred from breaking through. They concluded that chilli fences are more effective in low rainfall areas where rain does not wash off the chilli-grease from the rope. However they point to the fact that other confounding factors such as efficiency of guarding, elephant densities, etc. were not taken into consideration. It is therefore difficult to rely on these results as these other factors could be responsible for the difference in elephants breaking the chilli fences. What is interesting, however, is that most of the elephants which broke through the fence were males, and only once a female herd entered the crop fields through an opening left for the road. Hedges and Gunaryadi (2010) tested the impact of the chilli fence in a system which used guarding as the primary crop protection tool. They found no difference in the success between a section of the agricultural boundary guarded by community teams and another section which was guarded by the community but also supported by a chilli fence. They conclude that chilli-grease fences do not add any value to crop protection but do add the burden of extra costs and labor needed to install and maintain the chilli-grease fence. However Hedges and Gunaryadi (2010) ignore confounding factors; differences in the number of attempts to raid (57 versus 34) at the two sites are attributed to 1.1 ha. of maize grown at the site with higher raiding attempts. Similarly they do not explain a fivefold increase in the attempts to raid in the second year (from 0.33 raids/guarding night in first year to 1.59 raids/guarding night in second year) when only guarding was used as a crop protection tool.

Chilli-grease fences are being advocated as low cost tools for crop protection without any clear evidence that they can function as standalone barriers or even add some additional deterrence value to guarding. Logically one could argue that any man-made barrier, however flimsy would add some deterrence value. However, as rightly argued by Hedges and Gunaryadi (2010), the costs and the additional labor needed to manage the chilli-grease fences makes them very costly relative to whatever potential minor deterrence value they may add when guarding is used as the primary crop protection tool. The other arguments made in favor of chilli-grease fences are more in line with growing alternate crops which are not palatable to elephants. Elephants may eventually start eating or damaging chilli plants as minor amounts of feeding on chilli are seen in south India. Even when chilli is grown as an alternate crop, the use of chilli-grease fence cannot be justified due to the costs and labor involved. Additionally, what is generally not discussed is how elephants actually breach the chilli-grease fences. If typical of the pattern of elephants which break through EFs, where the fence post is the most attacked, then the chilli-grease fence will be more vulnerable as there are no means to protect the fence post.

Electric fence on boundary of a village and protected area. *Photo by Heidi S. Riddle*

Hence chilli-grease fences may not be effective against elephants in many situations. Most reports on the success of chilli-fences do not take into consideration deflection of elephants to other villages, and some are even tested on agricultural plots as small as 4 acres within a village. As such there is no compelling evidence for using chilli-grease fences as barriers against crop raiding elephants. The only exception would be in areas where crop raiding is purely opportunistic but in such areas (which may be very rare) other less expensive and less labor intensive methods would be better suited.

Trenches

Elephant proof trenches are expensive and labor intensive, but they can be effective in areas with suitable soil types and where HEC is very severe. Trenches are used as elephant barriers in many range countries in Asia. One of the benefits is that the cost to bid a trench is primarily labor; there is not a need to purchase expensive components as is the case with some other barriers (i.e. EFs).

Elephant proof trenches should be built wide enough so that an elephant cannot step over it and narrow enough so that an elephant cannot get into it. The shape of the trench is also important; walls should slope so that the bottom of the trench is narrower than the top. For a trench to act as a deterrent to elephants, the suggested dimensions are 3 meters wide at the top, 1 meter wide at the bottom, and 2 meters deep (Fernando et al., 2008). When planning a trench as an HEC barrier is it important to consider not only the design (shape) and dimensions of the trench but also local soil type (rocky or very soft soil), rainfall, existing roads, as well as natural obstacles such as streams that cut across the planned area of the trench. Trenches should be designed with some areas of increased slope in one side of the trench to allow elephants, particularly young ones who may fall in, to be able to get out – especially if walls are cemented.

Cement, plants, or stones can be used to stabilize, even strengthen the sides of a trench and prevent erosion. This increases the construction costs significantly. If a well-designed and well-constructed trench around a village prevents or minimizes HEC, it may be worth investing in construction costs if that barrier lasts long term and allows farmers to harvest their crops and not suffer loss of income.

As with other barriers, it is important to identify and address weak points in trenches that are used as an elephant proof barrier. The main concerns include: streams that cut across, water-logging, soil issues, poor design of the trench itself (width, depth, and shape), poor construction, no maintenance, etc. Trenches often fail due to mismanagement and lack of maintenance, as already discussed about other barriers, so it is important to address these issues.

Where trench or ditch type barriers for HEC are being considered, the use of planned or existing concrete canals (i.e. for irrigation) could also be incorporated into strategies to block elephants from crossing into certain areas.

Electric Fence (EF)

Currently the barrier most commonly used to mitigate HEC in Asia is the electric fence (EF). The first use of electric fences was in the early 1900s by the military to secure borders; these were lethal fences that could kill enemy soldiers. Bill Gallagher from New Zealand first introduced non-lethal electric fences for controlling livestock movement in 1936-37. The non-lethal electric fence has since evolved in terms of materials, cost reduction, and utility. The basic functioning is based on an 'energizer' which boosts a standard 12V battery charge to 6000 - 10,000 volts at low amperage and the current is sent as pulses (spaced ~1-1.2 seconds apart) with a duration of ~ 0.3 milliseconds. This gives a sharp but harmless jolt to the animal touching a live wire of the fence. This non-lethal shock pulse is what deters animals, including elephants, from trying to break through. It is now widely used throughout the world in controlling and/or containing the movement of livestock and wildlife.

The working principle is based on the fear of a novel and minor pain causing object that is generally avoided after the initial experience. It is therefore not a physical barrier but a psychological barrier. As such these barriers will work only if they are optimally maintained, elephants are not given needless opportunities to repeatedly test or habituate to the fence, and the fence is combined with guarding as a comprehensive crop protection strategy. Currently electric fences are widely used in Asia and Africa to control elephant movement and to contain HEC. Relative to traditional guarding methods and ordinary fencing, electric fences are expensive, but compared to mechanical or physical barriers that completely stop elephant movement they are cheap. Costs can be reduced depending on the material used and the design of the fence. But such cost reduction exercises need to consider the practical requirements which can be very site and purpose specific.

In Asia the success of EFs has been limited, and various problems have been reported, particularly in India and Sri Lanka (Balasubramanian et al., 1995; Bist, 1996; Desai, 1998). Failure can be largely divided into two categories: those occurring due to the limitations of the fence itself, and those due to human error. As already mentioned, electric fences are psychological barriers and this is their biggest limitation when they are exposed to elephants which have a tendency to explore, or when elephants are obligatory crop raiders. In the first case elephants learn that the shock is not dangerous, of very short duration and they then tend to break through such fences easily and become habitual fence breaking elephants. For example, Daniel et al. (2008) report a young male that repeatedly (11 times) broke an electric fence around a property that did not have any crops nor was the fence a barrier to free movement in the area as it only contained a farmhouse. In the second case, where elephants are obligatory crop raiders, they have no option but to try and breach the barrier and in the process of doing so they learn that it is not really harmful. In both the cases the crops on the other side of the fence are an incentive for them to break the barrier. Human errors that cause failure of electric fences are numerous and are discussed below.

Most people who implement EFs are not aware that the EF is not a standalone barrier for crop protection against elephants. It does not work in the same way for elephants as it does for other herbivores such as cattle, deer, antelopes, etc. For most animals an EF is both a psychological barrier and a physical barrier (to an extent), but for elephants it is only a psychological barrier as they are able to physically move it out of the way, either through intent or accidentally, and learn how to break through. Hence elephants that overcome the fear of electric shock quickly become habituated to breaking EFs. This process can be significantly hastened when the EF is poorly constructed or poorly maintained, thus making it easier for elephants to breach it in the first place. Once one or a few elephants learn to break through a barrier such as an EF, the knowledge or habit can be learned by other elephants in the population. Therefore, EFs are not standalone crop protection barriers and need to be supported by guarding at night. The added effect of guarding acts like a force multiplier and enhances the effectiveness of both guarding and the EF. Guarding essentially stops elephants from testing the fence so the learning process is curbed, and its presence between the elephants and people also emboldens people while making it more difficult, psychologically, for the elephant to overcome its natural fear of humans and the novel barrier. This combination of EF and guarding, a double deterrent, will also minimize crop damage even when habitual crop raiders or obligatory crop raiders are involved. Balasubramanian et al. (1995) recommended that EFs supported by guarding would be one of the best crop protection strategies.

► Implementing effective HEC barriers:

Assessing suitability and requirements

When identifying a suitable barrier for a specific HEC site, it is important to understand the limitations and suitability of the barrier itself. In the case of one of the most commonly used barriers, EFs, unfortunately many people who deploy or advocate EFs as crop protection barriers see them as standalone barriers and do not support them with guarding at night; hence EFs often fail. The problem is reinforced when government agencies and NGOs who implement EFs for communities inform farmers that EFs alone will solve HEC problems and guarding crops at night is not necessary. In fact many agencies promoting EFs mention that farmers claim they can get a good night's sleep (i.e. no guarding at night) as an indication of the success of the EF. This is often true in the first and second year when a new EF is seen as a novel object by elephants who initially hesitate to break through. But once they test it and learn to break it, unhindered by guarding, the problems escalate quickly and people then lose their faith in EFs and discontinue them. A major drawback with the approach of a fence as a standalone HEC effective barrier is that any existing practice of guarding is stopped; then a barrier that would function very effectively if combined with guarding is deployed, but neither system is effectively used. The misconception results in people and wildlife managers abandoning EFs once they are breached and branding the tool as ineffective. As fences are breakable, they need to be viewed as a barrier that reduces conflict rather than one that stops conflict altogether. As such a fence can bring about a significant reduction in crop loss.

When supported by guarding at night, even in the event of the barrier being occasionally breached, a guarding team can minimize crop loss by driving elephants out. In these situations it is important that the elephant(s) which have broken through are not haphazardly driven as they may then break out through another point damaging another section of the fence, especially if it is an EF. It is best to drive elephants back the way they have entered the crop fields. Once they are driven out it is important to assess how they were able to break through any barriers, to determine if it was the failure of protection, the early warning system, or some technical flaw in the fence that allowed them to breach the fence. Where the flaw is technical the fence needs to be especially strengthened in that section if required or the problem leading to the break should be resolved. Similarly any problem with the guarding should be addressed immediately. The fence or barrier would be repaired by those in charge of maintenance. In this scenario the community recognizes that some fences, such as EFs, are neither a standalone barrier nor a physical barrier and can occasionally be breached. This enables them to recognize the need to repair a barrier when it is breached and also recognize that the objective of barriers and guarding is to minimize crop damage rather than to eliminate it completely.

Another problem has been the inability to take an adaptive management approach to habitual crop raiders and obligatory crop raiders. In the case of habitual crop raiders which have learned to breach a barrier and to ignore guarding practices there is a need to develop a specific strategy to deal with such elephants. Such habituated elephants are few in number initially but, when left unaddressed, this learned behavior can be passed on to other elephants; this is particularly true for males. Only a perfectly working physical barrier can stop such elephants and it therefore becomes important that other strategies be developed to deal with such elephants rather that erect costly physical barriers just to address problems created by a few elephants. If this problem is not resolved then the presence of a few such elephants can undermine what could be a good and effective solution to crop raiding.

Fernando et al. (2008) point out that the success of any method being developed or used as an HEC deterrent needs to take into account not only the people's view (i.e. will it protect them from loss) but should also consider the elephants' perspective and broader conservation impacts, e.g. will a barrier escalate problems for elephants that may be on both sides of the barrier.

Design and planning

Poorly designed implementation and planning are a major cause for the failure of barriers. But it is important to understand the underlying issues that lead to poor design of a barrier layout. The general tendency of fences erected by government agencies to fail, as opposed to the successful functioning of privately managed barriers, has been highlighted by various studies (Balasubramanian et al., 1995; Gunaratne & Premaratne, 2006). This however is not a valid comparison and can be misleading as Daniel et al. (2008) show that government installed EFs were on an average 2075 meters long while private EFs were just 476 meters long. Not only are private EFs less than a fourth of the length of government EFs, the effective fence boundary exposed to elephants is only 25% of their length as the remaining three sides (or 75%) are flanked by neighboring agricultural fields. Thus the actual length of a private EF is just 119 meters as opposed to the 2075 meters of a government EF. Additionally the EF erected by government agencies tries to stop elephants from entering human use areas across a large area (its entire length) while a private EF being very short in length easily deflects elephants to adjoining unprotected crop fields. Given a 2 km barrier elephants are likely to try and break through rather than circumvent the barriers as opposed to circumventing a 119 meter long barrier. Hence it is important to recognize the differences in purpose and how elephants interact with them. A large part of the success of private fences is often due to elephants circumventing them when they have access to other unprotected or less effectively protected crop fields nearby. Hence it is important to review problems of longer barriers installed by government agencies separately from private fences. Problems associated with longer barriers are rarely found in shorter ones unless they are very poorly maintained and numerous weaknesses of shorter private barriers are often not visible due to the deflection of elephants to other adjoining areas.

Open ended fences

Barriers at the larger landscape level are deployed either as a circular fence surrounding a settlement/village or as a linear barrier along an extended forest-agricultural boundary. Even in the latter case the barrier or any combination of barriers/protection will either encircle a forest (to keep elephants in) or a large human use area (to keep elephants out). Hence crop protection at the landscape level is essentially a polygon enclosing or excluding an area which could be agriculture or elephant habitat. This generally gives the affected elephants only two choices, either to breach the barrier or to avoid stop raiding crops. Hence, obligatory crop raiders and habitual crop raiders are more likely to breach a barrier as they cannot bypass it to access crops anywhere else.

Inadequate funding can be one of the basic problems that can cause problems depending on the length of the barrier needed to enclose a human use area or an elephant habitat. Where the area to be enclosed is small, funding is generally available to install a barrier along the entire perimeter. But where the area is very large, inadequate funding may requires barriers to be installed in a piecemeal fashion over a period of several years, depending on available budget. This results in open-ended barriers which all elephants at either end of the fence circumvent to raid crops; it also results in channeling elephants to either end resulting in increased HEC. In such situations the government's efforts at providing local people adequate information on their strategy and also assisting them in protecting their crops from the increased influx of elephants by using other means results in people losing faith in the barrier. Their tendency is then to stop maintaining the fence or even damage it. It is very important to address such problems where barriers are open ended due

to budgetary constraints. Ideally communities at either end of an open ended barrier are made aware of the constraints and the plans for extending the fence at a future date. They also need to be made aware of the potential for increased HEC and assisted in dealing with it through improved guarding, availability of early warning systems, and help from wildlife/forestry staff to deal with such conflict. Extra efforts are also needed from the people managing and maintaining the barriers to ensure that they are not damaged or allowed to run down at the open ends.

► Challenges of HEC barriers:

Layout of HEC barriers

There are two major issues with the layout of HEC barriers, one has to do with where the barrier is erected and the other has to do with problems arising out of jurisdictional issues. Taking into account that some barriers (i.e. EF) are psychological and not physical barriers, it is important that those barriers psychological effect is enhanced by other factors that are available at the interface between human use areas and elephant habitat. This interface itself is a psychological barrier as elephants are aware that they are crossing into human use areas which is why they tend to do so only at night (in most cases). It is therefore important to exploit this effect by placing the barrier at the boundary where the agriculture starts or the open human use area starts. Often barriers are placed some distance inside the forest which results in the fence having good vegetation cover on either side. In such situations elephants only need to overcome the psychological fear of an electric shock as in the case of an EF, and the fear of entering open human use areas is not at play. Additionally this type of situation makes guarding difficult as there is less or no visibility of the fence from the open human use areas from where guarding is done. It also hinders maintenance of a fence such as an EF as vegetation on both sides of the fence increases maintenance work and requires maintenance staff to walk through vegetation cover with the possibilities of encountering elephants. Poor visibility and difficulty also reduce the motivation of the maintenance team. Such placement of a barrier is either due to a design flaw or due to fallow land or unmaintained village common land lying between the open human use areas and the forest.

Therefore, it is very important to work closely with the communities involved to iron out any difference about erecting a barrier on the boundary of their properties (if any) so that design flaws do not reduce the efficacy of the barrier. Where densely vegetated fallow land or community land exists between open human use areas and forest, it is important to decide with the community and individual owners about either excluding such areas from the fenced area or to clear all vegetation in such areas if they are included in the fenced area.

Electric fence backed by stone wall in Bannerghatta National Park, Karnataka, India. *Photo by Heidi S. Riddle*

On a larger scale, jurisdictional issues arise when forests (elephant habitat) fall under the management of different agencies. For example, in India forest land is largely under the management of the Forest Department but some areas are under the

management of the Revenue Department. In Sri Lanka, the wildlife conservation areas are under the management of the Department for Wildlife Conservation, and other forest areas are under the management of the Forest Department. Where an elephant habitat is partially under two different jurisdictions, wildlife managers have sometimes taken an unsound approach and fenced off the area under their jurisdiction, thus dividing the elephant habitat and population with elephants on both sides of the barrier. While such blatant errors in erecting barriers seem unimaginable, they do happen and point to the need for a more serious, sensible, and holistic approach when designing the layout of an HEC barrier.

Managing and maintaining HEC barriers

Responsibility for management and maintenance of the barrier is critical as the efficacy of the barrier is entirely dependent on its proper functioning. Balasubramanian et al. (1995) mention that most fences erected by government agencies and NGOs failed due to poor management. Poor maintenance due to poor management is a major reason for the failure of many barriers. In most government installed barriers there is no direct responsibility for ensuring the proper function of a barrier. In fact, in countries like India, a fence is not treated as a capital asset in the accounting and as such no one is held responsible for its failure or its complete disappearance over time. As a result, no attempts are made to safeguard proper maintenance of the barrier, and community participation to support the fence by guarding at night is not required. Hence this approach is flawed and almost guarantees that the barrier will fail. This can only be corrected if responsibility for managing and maintaining the barrier is clearly assigned to some entity and that entity is held responsible for the proper functioning of the barrier. It is important that either the implementing agency or the community is made responsible for maintaining the fence. In addition, a proper monitoring and reporting framework also needs to be implemented to ensure that maintenance does not slacken and any problems are detected and addressed quickly.

The absence of stakeholder involvement from design and construction, to management and maintenance is the cause of a lot of failures of HEC barriers. Other than informing stakeholders that a government agency plans to erect a barrier for their benefit, stakeholder involvement is by and large missing. Stakeholders are not just the farmers but also people engaged in other livelihoods and dependent of the forest for various resources. When the interests of cattle grazers, fuel wood collectors, and non-timber forest produce are not taken into account when erecting a barrier, the paths and access that these people use to enter the forest are often cut off and in turn they tend to break the barrier or at the very least compromise its integrity (i.e. by pressing down EF wires), or fill in a section of trench to allow passage into the forest. As livelihood requirements are totally different, interacting only with farmers and ignoring other requirements results in the barrier being compromised. It is therefore very important that all stakeholders are consulted and their interests taken into consideration. Gates can be installed to facilitate movement of cattle and people to enter the forest at agreed to locations along the periphery of the village. The costs of creating a few additional openings in a barrier far outweigh the costs of the entire barrier failing because some stakeholders are not taken into account.

Managing and maintenance of an HEC barrier has to be a joint effort between government agencies responsible for erecting the barrier, the community, and the elected representatives of the village and the district. Barriers by and large protect the farming community, but communities are not entirely made of farmers. Interest in maintaining barriers declines or is lacking among people who are not farmers, unless their lives are threatened by HEC in the area. Even among farmers, those with farms on the periphery of the village are more prone to crop raiding than those whose farms are deeper inside the agricultural area. Farmers on the interior tend to be less interested in the maintenance and management of barriers as they are generally not exposed to crop raiding.

This can be a serious problem when resources (money and time) needed for maintenance involves the whole community. Failure to contribute or participate in the management and maintenance by a section of the community can result in the failure of the barrier. Therefore it becomes necessary to involve the elected representatives of the community to ensure that all people participate. The government agency entrusted with the management of elephants and for the erection of the fence automatically becomes a major partner in any such activity. Alternately, where the entire community is not involved in the management and maintenance of the barrier, those directly benefiting from the barrier can form a 'fence user group' which is then responsible for maintenance. Here it is still important to involve the elected representatives to maintain cohesiveness within this group as most communities are not homogenous and can be divided along social, cultural, political, and economic lines. Where management and maintenance is done by the government agency involved in erecting the barrier, the community, the elected representatives, and the civilian administration must still be involved in monitoring the management and maintenance of the barrier to ensure that stakeholders' needs are adequately addressed. Even where private agencies are involved, stakeholders, elected representatives, and government agencies charged with elephant issues need to be included.

In some cases wildlife authorities try to resolve anthropogenic pressures on wildlife by ignoring stakeholder needs. While this approach attempts to stop HEC and anthropogenic pressure with one solution, it often fails to serve either purpose as people either damage the HEC barrier or compromise its functioning resulting in elephants breaking through. The problem of anthropogenic pressures on wildlife habitat needs to be addressed separately through different strategies which do not include HEC mitigation.

Key Considerations

Barriers and Deterrents

- When identifying a suitable deterrent for a specific HEC site it is important to understand the limitations and suitability of the tool itself.
- Poorly designed planning and implementation are a major cause for the failure of HEC deterrent tools.
- Open ended barriers due to inadequate funding may deflect the problems of HEC to other areas.
- It is important to work with communities to properly layout HEC deterrents/barriers and address jurisdictional issues.
- Poor maintenance due to poor management is a major reason for the failure of many HEC barriers.
- When using barriers for HEC it is important to consider how these barriers will affect elephants' ranging and resource use so as not to escalate HEC instead of mitigating it.
- HEC mitigation is greatly improved through linkages of government with farmers, community stakeholders, and science.

SECTION 4: Compensation

Compensation is a reactive strategy to support communities living in or near elephant habitat and who suffer loss due to HEC. In this document the focus is on compensation for loss of human health, life, or property as a direct result of HEC. Compensation schemes in Asian elephant range countries are broadly divided into two types: 1) direct support which occurs when people receive payment for injury, loss of life, property and/or crop damage as a result of HEC, and 2) indirect support that may be in the form of developing alternate incomes, improving existing incomes, or improving livelihoods to provide indemnity for losses due to HEC and encourage better community participation in elephant conservation.

Direct Support

► Origin and current application in HEC mitigation:

When guarding or barriers are not able to contain elephants and they cause conflict, assistance to support those people directly affected by injury or loss of life or property or crop damage has been provided. This support is generally provided in the form of monies or goods given as payment or reparation for injury or for loss of human life, property, or crops. This is done in the form of payments via either compensation schemes or insurance schemes; it is important that any remuneration be adequate and timely. This compensation strategy is intended to increase people's resilience to HEC.

► Operating principle:

Compensation payments are a scheme under which an individual or household is remunerated for loss due to elephants (injury, and/or loss of life, and/or property, and/or crops) as per existing rules and regulations. There is no financial contribution expected from the affected individual or household. Government based compensation schemes exist in Asian elephant range countries and vary in type *(see table on page 59)*.

Village house damaged by elephants, Assam, India.
Photo by Elephants on the Line

Compensation schemes can be very costly; a study in one state (Karnataka) in southern India indicates that during an almost

3 year period the state government paid approximately US$3 million to cover loss of crops and loss of life due to HEC. During that same period 91 people and 101 elephants died as a result of HEC (Gubbi et al., 2014). Compensation is complex and not always effective; individuals and/or communities often do not file claims for compensation due to numerous obstacles, i.e. lack of awareness of the scheme, time consuming, logistically complicated, gender based restrictions, and unclear property ownership (Ogra, 2009). As a major HEC mitigation tool, compensation should be viewed as a short-term approach; eventually compensation should be replaced by other strategies and used only to support severely affected people so that they can overcome crisis situations.

Insurance is a mechanism where a premium is paid by an individual, a household, and /or a community in exchange for reparation for loss (e.g. injury, loss of life, property, or crops) from HEC under previously agreed conditions of protection and payment. There is generally a third party involved that assesses the amount of the premium based on a set of variables such as crop type, willingness to guard, crop protection mechanism, etc. An insurance payment is usually proportionate to the risk of the insured activity.

Insurance schemes to address loss due to HEC may help reduce public animosity towards elephants as insured farmers may feel they have a better chance of receiving reparation for losses. Insurance may be less likely than compensation to lead to abuse of the system as insurance schemes are more transparent. Assessor staff should be well trained and neutral to best determine the validity of the claim. Insurance operated by private companies may reduce the pressure on governments to solve HEC problems through compensation schemes, and governments may be able to use compensation funds to address other HEC management issues.

► Management of HEC compensation and insurance schemes:

Compensation schemes in Asian elephant range countries are generally funded and managed by government. However, compensation schemes could be managed and funded by a combination of agencies such as government, private sector, INGO/ NGO, and local community. Insurance schemes are generally managed and funded by private parties, but, as with compensation, a combination of private and government support should be considered (Chen et al., 2013). Management of these schemes can be in the form of providing support (i.e. funds) and/or administration. In cases of international transboundary issues of HEC it may be advisable to develop schemes that are both government and INGO based to facilitate transboundary compensation (i.e. payments).

Funds sourced from industry to support these schemes could be administered by an agency within industry, government, or NGO. Some examples: large scale plantations on the edge of PAs could be asked to provide a percentage of profits in a fund for HEC compensation (Chen et al. 2013); a portion of compensation from industry projects (i.e. hydropower) that is provided for PA management could be used for compensation payments for HEC.

Funds could be generated from tourism (Chen et al., 2013). A recent IUCN report indicates that PAs around the world generate over $600 billion per year in revenues, but only 2% is spent on their protection (IUCN, 2015). To better protect PAs, it is important to invest in local communities who suffer loss due to wildlife conflict to reduce animosity towards the conservation of wildlife. National Park and PA entry fees are administered by government, but community based tourism in those areas should be encouraged to provide a portion of proceeds from managing private lodges, tour operators, etc. to set up a fund supporting the local community for losses due to HEC.

► Disadvantages of HEC compensation and insurance schemes:

Compensation and/or insurance schemes are reactive measures but do not resolve HEC or crop damage. In fact, these schemes may have the unintended effect of increasing HEC losses as payments to farmers to cover losses may result in less guarding or less crop protection. Compensation and insurance schemes are expensive and complex to administer as there is generally a need to cover large areas, identify and properly train assessors, educate farmers about the scheme, and manage the finances. Oftentimes there are insufficient funds to cover all complaints. Furthermore these types of schemes can be abused by false or inflated claims of loss, by crops being planted in areas where they are more likely to be damaged, and by assessments of HEC incidents that are not neutral. Poor administrative processes and corruption can deprive people from receiving reasonable and timely compensation, and payments to only some victims may cause disputes amongst communities. Ultimately, compensation may use funds that would have been better directed at other HEC management issues. Insurance schemes need to keep pace with changing circumstances; for example, an insurance premium may need to increase after a single claim. The biggest challenge to farmers for insurance schemes is the premium cost and the decision to use resources that may be better spent on other aspects of HEC mitigation.

Key Considerations

Direct Support

- Compensation is a complex issue for addressing losses caused by HEC; insurance is still a novel idea to address the same issues and requires further investigation in Asian elephant range countries.
- As with all HEC mitigation tools, a periodic review and assessment process is needed to identify if and when the use of compensation and/or insurance schemes are suitable.
- It would be helpful to review existing compensation and insurance schemes to develop a structure for potentially applying and monitoring such schemes for HEC losses in Asia.
- Compensation schemes could be reviewed to offer HEC relief schemes that do not provide monetary support but offer other forms of support (as during natural disasters) such as food and/or livestock, the provision of aid to fix or replace water supplies and/or food storage facilities and/or fences, etc.
- Besides evaluating the efficacy of compensation and insurance schemes, an assessment is needed to determine whether such schemes actually result in attitudinal changes of local communities (i.e. increased tolerance towards elephants).

HEC Compensation and Insurance Schemes in Asian Elephant Range Countries

COUNTRY	COMPENSATION BY PAYMENT	INSURANCE
Bangladesh	Compensation scheme exists for crop or property loss, injury, and loss of human life.	No insurance scheme currently exists.
Bhutan	No cash compensation for crop loss, farmers are given seeds. Small cash condolence payment given for injury or loss of human life.	Recent crop insurance scheme initiated with seed money from the government; a farmers' committee runs the scheme.
Cambodia	No compensation scheme currently exists.	No insurance scheme currently exists.
China	Compensation scheme exists for crop loss, injury, and loss of human life.	Recently initiated crop insurance scheme is managed by an insurance company.
India	Compensation scheme exists for crop loss, injury, and loss of human life, but referred to as "ex-gratia relief".	State governments have attempted insurance schemes but were unsuccessful.
Indonesia	Compensation scheme exists for loss of human life but not for loss of crops.	The government pays a premium for life insurance for 100 people every year, then pays for loss of life due to human-wildlife conflict. One province (Aceh) covers injury due to wildlife conflict in their provincial health insurance scheme. A crop insurance scheme was trialed by an NGO in Sumatra; farmers did not participate due to high premiums.
Lao PDR	No compensation scheme. Voluntary contributions may come from communities or agencies for loss of life.	No insurance scheme currently exists.
Malaysia	Limited compensation. In peninsular Malaysia there is some compensation for injury or loss of life, but not for crop loss. There is no compensation scheme in Sabah/Borneo.	No insurance scheme currently exists.
Myanmar	Compensation scheme exists but only covers crop loss, not injury or loss of human life.	No insurance scheme currently exists.
Nepal	Compensation scheme exists for injury, loss of human life, and property damage. No compensation paid for loss of crops, although the legal provision exists.	No insurance scheme exists, but community based mechanisms are currently being piloted in some areas.
Sri Lanka	Compensation schemes exist for crop loss, injury, loss of human life. Schemes are managed by different government agencies.	No insurance scheme currently exists. An attempt to offer insurance to farmers was unsuccessful.
Thailand	No formal compensation scheme exists, however at the local level there may be some support for loss due to "natural disaster".	No insurance scheme currently exists.
Vietnam	No compensation scheme currently exists.	No insurance scheme currently exists.

Indirect Support

► Origin and current application in HEC mitigation:

Indirect support was developed as a means to provide assistance to develop, support, and/or implement ways to address income loss caused by HEC, with the intent of increasing peoples' resilience to HEC. This approach supports developing alternate sources of income, or it may focus on enhancing and improving existing sources of income (e.g. improving marketing options for existing crops to increase income), and/or improving livelihoods. Indirect support for crop loss through increased incomes from other sources reduces dependency on a single source of income (subsistence agriculture).

Any type of indirect support scheme needs to be regularly and systematically evaluated to determine its efficacy and assess if the scheme has a positive impact on people's attitudes and behavior towards HEC. Certain challenges exist in implementing these schemes as programs need to be carefully designed to avoid providing incentives that would encourage habitat conversion in PAs by increasing cash income through enhanced crop or livestock production within these areas. These schemes are more effective when local grassroots NGOs and non-forest government agencies (i.e. rural development) cooperate to support and raise local communities' awareness of alternate livelihood options. Such partnerships can better influence villagers involved in using forest resources for illegal activities (poaching, logging, etc.) to participate in supporting forest protection (i.e. by patrolling PAs, informing about wildlife crime, etc.) thereby helping to reduce tensions between Forest authorities and local communities. If livelihoods cannot be reasonably enhanced, wildlife managers may need to consider options to reduce HEC by relocating communities away from protected areas.

► Operating principle:

Alternate sources of income may be considered in cases where households and/or communities continuously suffer relatively high levels of income loss due to HEC. Methods of **improving income from existing sources** may also be considered in such cases. Assistance is provided to recover the loss due to HEC and/or to help develop positive attitudes towards the conservation of elephants and their habitats. Examples and considerations of alternate income sources and for improving income from existing sources include the following:

1. AGRO-FORESTY RELATED

Examples:
- Worm composting which is sold to forest nurseries and tea gardens (India).
- Home gardens for sale of fruits and vegetables (i.e. jackfruit, wood apple, etc.) established a great distance away from elephant areas and meant to improve incomes (Sri Lanka).

Considerations:
◊ Planting species that increase HEC in or near elephant areas should be avoided.
◊ Alternate cash crops that have the tendency to contribute to habitat loss and rapid encroachment (e.g. oil palm, rubber) should be avoided.
◊ The use of potentially invasive species should be avoided.

Women's group weaving as an alternate livelihood in fringe zone of Manas National Park, India.
Photo by Pranjal Bezbarua

2. CULTURAL/HANDICRAFT RELATED

Example:

- In cooperation with the government Rural Development Department, women in fringe zone communities of a National Park were trained in weaving and provided in-kind support for looms and building materials. The weavings are sold in local markets (India).

Considerations:

◊ Need to assess if such programs lessen the dependency of trainees on forest resources.
◊ Local community programs supported by both government agencies and local NGOs are more successful long-term.

3. ECO-TOURISM RELATED

Examples:

- Local residents are given training in field research methods (GIS, compass, field data collection) as Field Scouts/Community Rangers. Trainees monitor HEC mitigation methods and alternative income schemes. Earnings from tourism activities are used to hire Field Scouts/Community Rangers and pay for village-assistance activities (i.e. fences) to prevent HEC (Sri Lanka; Sumatra-Indonesia).
- Money generated from tourism is channeled into compensation schemes and HEC mitigation activities (Nepal).

Considerations:

◊ Programs need to be aware that tourism is a volatile market dependent on regional security as well as

political and economic situations beyond control.
◊ Need to consider and properly manage tourism pressures in PAs.
◊ Community based eco-tourism programs are generally more successful long-term than NGO driven projects.

4. NON TIMBER FOREST PRODUCTS (NTFP)

Example:
- Wild bee honey harvested in a PA during the dry season to determine if increasing income from such a harvest leads to increased tolerance of PAs (Sri Lanka).

Considerations:
- Need to assess if harvesting wild honey or similar products in PAs would be a potential source of HEC.

5. IMPROVED AGRICULTURAL PRACTICES

Providing alternate crops or providing better crop protection in order to allow farmers to harvest their crops even in the presence of elephants.

Examples:
- A village erected a fence to keep elephants out of crops; this enabled households in the village to increase income from agriculture, thereby allowing them to send their children to receive an education (Sri Lanka).
- The use of solar powered fencing or bio-fencing using thorny plants has been successful as crop protection measures in some fringe zone villages (India).

Considerations:
◊ Improving existing agricultural practices could magnify HEC if elephant behavior is not properly considered; planting species that increase HEC in or near elephant areas should be avoided.
◊ Alternate cash crops that have the tendency to contribute to habitat loss and rapid encroachment (e.g. oil palm, rubber) should be avoided.
◊ The use of potentially invasive species should be avoided.
◊ Solar powered fencing and bio-fences need regular maintenance investments to be effective.

6. IMPROVED MARKETING OR VALUE ADDITION

This method adds incentive for villagers to 'process' crops one step further in order to get a better return for the sale of their crops.

Examples:
- Producing coffee in areas "certified not grown in protected areas" allows for a higher price for this coffee. This encourages farmers not to encroach protected areas to grow coffee (Sumatra-Indonesia).
- The Elephant Pepper Development Trust (www.elephantpepper.org) was formed to add value and improve marketing in order to increase income through existing chilli production (Africa).

Consideration:

◊ It is recommended to involve an interdisciplinary team or business specialists to assess and develop marketing strategies before engaging in improving marketing or adding value to existing agriculture production.

7. MICRO-FINANCE AS A TOOL FOR IMPROVING INCOME

Adding micro-financing may provide incentive to people to adopt low risk HEC livelihoods, raise their income, and may be used in cases where crops fail to be harvested.

Examples:

- With seed money and free training provided by an NGO and government agency, women from households were given a piglet to raise and sell. The beneficiaries formed a group and deposited a small amount of monies into a common fund. The money from selling pigs and from self-contributions established a savings/credit scheme for women to take out short-term loans. (Nepal; India).
- As a pilot project a micro-credit fund was established with several villages in key communities around elephant areas. An NGO provided funds as agricultural grants for farmers to seek alternative farming. The farmers manage the fund as groups of households. Most households in the area have since joined and have shifted agriculture practices (China).

Considerations:

◊ Micro-financing schemes need transparency to remain successful when savings get too high. Insurance policies for crops could come out of micro-financing options.

◊ Micro-financing schemes seeking to encourage farmers to try alternate farming may be more successful in areas where traditional agriculture is practiced.

◊ Individuals who will receive training and livestock should be identified and selected from local forest dependent communities.

◊ Adequate training in implementing and monitoring such schemes needs to be provided to the local communities.

Women receive piglets as part of a micro-finance program in India.
Photo by Pranjal Bezbarua

8. LIVELIHOOD IMPROVEMENT LINKED TO REDUCING HEC

Livelihood improvement linked to reducing HEC can be achieved by improving the quality of life of individuals, households, and/or communities near PAs. Assistance is provided to mitigate negative impacts on livelihoods due to HEC.

Examples:

- When communities near PAs protect habitat for wildlife, people living in these communities receive free or subsidized health care. The level of payments is based on how much habitat protection and/or restoration the individual and/or household is doing (Kalimantan-Indonesia; Nepal).
- School fees are paid for families that have suffered loss from HEC (Nepal; Sri Lanka).
- Children from families suffering from HEC have first opportunities for jobs in the protected area system (Nepal).
- Local communities who volunteer for conservation activities in PAs (i.e. forest patrolling, habitat restoration, informing about wildlife crime) receive a small stipend or free rations (India).

Considerations:

◊ Individuals who will receive training in habitat protection and/or restoration should be identified and selected from local forest dependent communities.
◊ Adequate training in implementing and monitoring habitat protection and/or restoration needs to be provided to the local communities.
◊ Need to evaluate the assessment tool used for measuring the level of habitat protection and/or restoration.
◊ Need to establish monitoring mechanisms for selection of individuals and proper management of conservation volunteer programs to prevent forest resource exploitation.

Key Considerations
Indirect Support

- As with all HEC mitigation tools, a periodic review and assessment process is needed to identify if and when the use of indirect support schemes is suitable.
- It would be helpful to review existing programs to develop a structure for potentially applying and monitoring such schemes in Asia.
- There is a need for quantifiable data on income from such programs, linkage to reduced HEC, change in peoples' attitudes and practices, and tolerance for elephants.
- Organizations or groups seeking to establish indirect support schemes should collaborate with local communities and various government agencies to develop, implement, and monitor such schemes in a transparent manner, in order to be effective long-term.
- There is a need to assess and help identify or develop markets for products grown or produced through indirect support schemes.

SECTION 5: Impacts of Human-Elephant Conflict

The impacts of HEC largely occur when people intrude into elephant habitat or elephants intrude into human use areas. This section discusses the challenges faced in HEC mitigation which mostly relate to human issues. The human factors range from simple lack of capacity (at all levels) to corruption, apathy, and governance issues. This section identifies the impacts HEC mitigation has on elephant conservation, and the situations where addressing conservation issues remains challenging.

Minimizing Loss and Damage

The basic cause for HEC, habitat loss and fragmentation, has not been stopped. With ongoing habitat loss and fragmentation HEC will continue to increase. In addition poorly planned development has fragmented habitat and created a diffuse interface area between human use areas and elephant habitat; both of these exacerbate HEC even further. Thus the current challenges are to minimize intrusion (of elephants into human use areas and vice versa) and lower the risk of loss from HEC so that any damage suffered is minimal, bearable, and acceptable to the people directly affected.

► Minimizing elephant intrusion into human use areas

To prevent or minimize elephants coming into human use areas, physical and psychological barriers and safe passage mechanisms should be used at critical places to facilitate the safe use of such areas by humans. In agricultural areas, active crop protection requires people being actively involved in the process of crop protection in the field. This involves proactive protection along the effective human use - elephant habitat boundary throughout the crop season (year round in the case of agro-forestry crops), or during the entire crop raiding season where raiding by elephants is seasonal and predictable. In reality much of the active protection in the field involves reactive protection that focuses on driving elephants out of crop areas only after they have entered and started damaging the crops fields. Passive methods of crop protection are defined as those that do not continuously require people being present in the field and confronting elephants. This involves creating physical (or psychological) barriers or deterrents between elephants and crops *(See Section 3)*. In some cases it also involves shifting to agricultural or non-agricultural practices that do not attract elephants.

In the case of small farmers, elephant intrusion can be minimized through community based crop defense. In low conflict areas guarding/patrolling *(See Section 3)* along the periphery of the agricultural area can be used. This method can be supported by the use of trip wires that set off alarms, allowing the guards to rest and ensuring that most elephants are detected when they try to cross into agricultural areas. The use of secure ground hides or tree platforms will further enhance protection especially if there are fires lit. Noise making devices may also have to be used. In the case of high conflict areas, electric fences supported by guarding will be the ideal means of

crop protection. As small communities of marginal farmers cannot afford purchasing equipment such as electric fences, support in the form of materials should be provided to these communities by the government and/or NGOs or other donors.

For companies managing large scale plantations or other development, the best methods to minimize elephant intrusion would be to use elephant proof trenches or electric fences or a combination of both. The usefulness of these barriers depends to a large extent on the effective application and maintenance of these methods. It is generally poor application and maintenance that allow crop raiding when these methods are applied. Company owned plantations are a significant cause for HEC; it should therefore be the companies' responsibility to manage their own crop protection measures. Government and/or NGOs should limit their assistance to providing technical help when required by these companies.

Dead elephant due to poisoning in a plantation, Bengkulu Province, Sumatra. *Photo by Seblat CRU*

► Minimizing human intrusion into elephant habitat

Administrative problems brought about by jurisdiction and management issues, and the absence of stakeholder involvement has resulted in elephant habitat being fragmented, and humans increasingly intruding into elephant habitat. There is a need to manage buffer areas to create an interface that is more conducive to HEC mitigation and minimizes human intrusion into elephant habitat. This requires changes in existing land use; hence the government needs to be a key player in any attempt to change land use to better suit HEC mitigation work. Other stakeholders (i.e. local communities, private companies) will also have significant roles to play in this activity.

Land use planning should create distinct elephant habitat areas and human use areas. Distinct boundaries between these areas have several advantages: they lend themselves to the erection of elephant proof barriers, reduce the manpower required to guard the boundary, and reduce the costs as they greatly reduce the length of the interface area. Large and highly fragmented areas where the landscape is a mosaic of human use areas and elephant habitat (with inadequate size) are the ones with the most serious HEC. These areas have the least potential for elephant conservation as the whole area is affected by conflict. Changes in land use in order to establish hard boundaries would be too large to be feasible (socially or economically). Small patches of elephant habitat amidst human use areas can act as bases from which elephants will raid crops. Such habitat pockets and the elephants using them are responsible for very severe HEC, especially when the remaining habitat is insufficient to support the elephants. These habitat patches should be eliminated as the cost of containing elephants that use them will be very high; it will also be very difficult or impossible (and ecologically unsound) to keep elephants confined in these small forest patches. Elephant populations in such areas are destined to die out from stress and reduced reproductive success, as well as from retaliatory killing by local people.

► Co-existence in an elephant inhabited landscape

The increasing human population moving into elephant habitats is often times naive about the notion of co-existence when living in an elephant inhabited landscape. Awareness programs should help educate all people living in or near elephant habitat to improve their understanding of wild elephants so as to avoid confrontation and conflict whenever possible. There is a need to understand peoples' tolerance or intolerance levels towards problem elephants, and the socio-economic and ecological factors driving the attitude. Effective awareness programs can bring about attitudinal and behavioral change among people living in or near elephant habitat, so that conflict is minimized. Where systematic avoidance of conflict is not being practiced by communities, co-existence is an important theme as no other methods of protecting humans (or elephants) seem to be working consistently.

Effective crop protection at the individual farmer and/or community level is often not applied as people lack both awareness and capacity. The need for systematic and sustained crop protection is not well recognized, and most methods employed are reactive methods that seek to detect and drive elephants out of crops only after they had entered the fields and started damaging crops. This approach significantly increases the amount of damage and also the number of elephants raiding. Once elephants enter fields they may be harder to dislodge as they have access to good fodder and that may be an incentive to hold their ground when people try to drive them away. Even when there is early detection it results in some damage as elephants are driven out only after they have already entered fields. Poor application of protection methods results in farmers giving up on trying to mitigate HEC and taking other, much more drastic, measures such as retaliatory killings of elephants. This has become a significant problem for the continued survival of some elephant populations in Asian range countries.

Besides crop protection, local communities need to be made aware of the need to secure property (house, grains, etc.) from elephant damage. Property loss in the form of houses or other structures damaged by elephants when they were raiding crops is also prevalent. Damage may occur when elephants seek out stored salt or food grains, but elephants have been known to damage man-made structures for no apparent reason. Property damage has the potential to result in human injuries or deaths, as there is a possibility of accidental or intentional harming of people by elephants if the people are caught unaware when elephants damage houses.

Key Considerations

Minimizing Loss and Damage

- To prevent or minimize elephants coming into human use areas, barriers and safe passage mechanisms should be used at critical places to facilitate the safe use of such areas by humans.
- In the case of small farmers, elephant intrusion can be minimized through community based crop defence.
- Boundaries should be managed to create an interface that is more conducive to HEC mitigation and minimizes human intrusion into elephant habitat.
- Land use planning should create distinct elephant habitat areas and human use areas.
- Effective awareness programs can bring about attitudinal and behavioural change among people living in or near elephant habitat, so that conflict is minimized.
- Effective crop protection at the individual farmer and/or community level is often not applied as the people lack both awareness and capacity.
- Besides crop protection, local communities need to be made aware of the need to secure property (house, grains, etc.) from elephant damage.

Management Issues

The major reasons for the failure of HEC management measures have been due to human factors such as public and governmental apathy, inability to take responsibility, poor understanding of HEC and elephant behavior, poor application of mitigation methods, inability to take an adaptable approach, and the inability to sustain HEC mitigation efforts. The management of existing HEC situations calls for an integrated, flexible, and committed approach from all stakeholders so that the most appropriate tools are applied effectively and in a sustained manner.

► Lack of capacity

Governments in Asian elephant range countries need to have a clear policy on HEC management and elephant conservation; this is not always the case. Based on interviews and direct observations from the field at various sites in Asian elephant range countries it is clear that there are flaws with attempts at HEC mitigation by communities and/or private companies and the government, and there is little systematic and sustained proactive crop protection. Effective crop protection at the individual farmer or community level is often not applied as people lack both awareness and capacity. In many cases, much of the protection is limited to driving out elephants once they enter crop fields. The major reasons for this attitude and situation are that local people report they have little knowledge about elephants, are afraid of elephants, and do not know how best to protect their crops on their own, however they are usually willing to apply crop protection measures if trained to do so.

In some Asian elephant range countries where HEC mitigation methods (i.e. translocation and capture) used by the government eliminate elephants from HEC sites, the need to develop the capacity among local communities to co-exist with elephants is not seen as an integral part of agricultural practice in an elephant inhabited landscape. This direct and high profile government involvement in HEC mitigation and the absence of capacity building to enable local people to protect crops results in people becoming overly dependent on the government to deal with HEC. Not only does this approach fail to resolve HEC, it also creates a mindset among people that it is the government's task to resolve HEC. This attitude needs to be changed if HEC mitigation and elephant conservation are to succeed, as the responsibility to manage HEC falls on government and various stakeholders (i.e. local communities, private enterprise, conservation NGOs) to cooperatively work to address conflict.

Capacity building

Capacity building has to be an integral and basic component of any attempt to address HEC; however there have been few attempts at long-term programs that build capacity to manage HEC in a meaningful way. Understanding where and how to build capacity is important; programs need to address various government levels, various government departments, local communities, private enterprise, and conservation organizations. Building capacity is not only sharing information and raising awareness, it is also helping to provide technical assistance, tools and/or the mechanisms to implement, maintain, and monitor any aspect of HEC management. Programs should also build local capacity of farmers and communities to become self-reliant in crop protection.

Awareness

The various local stakeholders (farmers, communities, plantation owners, etc.) are not aware of all the issues that lead to HEC, yet the bulk of HEC mitigation work (crop protection) usually falls on them. The biggest hurdle to effective HEC management is that people have not been informed

about how to deal with conflict and expect the government to resolve HEC problems. The government alone cannot resolve HEC. Many people now living in elephant landscapes moved into those areas and are naïve about elephants and about HEC. The fact that crop protection (time, effort, and costs) is an integral part of agriculture in an elephant inhabited landscape is unknown to them. This problem needs to be addressed through increased and improved awareness and educational programs about wild elephants and HEC. Programs should effect attitudinal change of people towards HEC and conflict mitigation, and make them more responsive to crop protection at the individual and community level. Such awareness programs should target government agencies and local stakeholders, and would help bring about a more comprehensive understanding of HEC management.

Public and government

Stopping the root causes of HEC, habitat loss, fragmentation and degradation, through effective land use planning and public policy is critical. Most Asian elephant range countries have weak conservation frameworks and implementing agencies in place. Efforts should be made to increase public awareness about these issues so that advocacy and lobbying ensure government commitment and involvement in making land use planning an integral part of policy on elephant conservation and HEC mitigation. Governments need to involve wildlife and environmental sectors in the planning processes. Advocacy should also target policy makers so that they are aware of the problems faced by local communities and so they become more knowledgeable about elephant conservation and HEC. Environmental conservation efforts and land-use planning policies rely heavily on the decisions of legislators. Yet in a survey of civil society organizations working in Aceh, Indonesia, only 4% stated that their target audience is legislators (ACCI-ACEH, 2014). Without a sufficient base of knowledge and a high level of awareness amongst legislators it is unrealistic to expect that conservation needs will be fully met. Currently novel programs seeking to engage legislators in environmental issues have been initiated in several Asian elephant range countries. These programs provide technical and scientific consultation to legislators on a variety of issues such as land-use planning, and facilitate the flow of conservation information from civil society organizations to legislators in order to enhance the development of public policies.

Media (press and social) brings conservation issues to the attention of decision makers and the public. Media also guides actions and can effect changes in policy through public awareness campaigns. While media operates differently across regional, national, and international scales and does not improve capacity, it does play a role in informing policy makers about HEC management, reinforcing public perceptions of these issues, and could potentially lead to better implementation of conservation policy (Barua, 2010). Communicating and engaging with the media allows the multiple facets of HEC to be presented, and keeps government decision makers and the public better informed.

► Lack of cooperation

There should be more collaborative approaches in managing species of common interest. Coordination and interaction among various government departments and the various stakeholders is important to elephant conservation and to HEC management. There is a need to improve and institutionalize cooperation and coordination within various government agencies, and between policy makers and the local community. The lack of cooperation is a major constraint in HEC mitigation and needs to be addressed in a serious manner through awareness and capacity building. Increased transparency in decision making and the involvement of multiple stakeholders in the decision making process is crucial.

Additionally, the need for cross border cooperation between countries who share elephant populations is essential for establishing and managing cross border PAs, for monitoring elephant populations and their habitat, and for addressing HEC problems. The issue is important as most Asian elephant range countries

share cross border elephant populations. Without well-structured mechanisms to facilitate interaction and cooperation it is difficult to achieve successful cross border cooperation, especially at lower management levels.

Within communities

Coordination should be developed within local communities to bring about a more positive relationship between people to address HEC issues collaboratively. Farming communities are often not well organized nor adequately committed to cooperative crop protection efforts; this results in the failure of effective implementation of HEC mitigation tools. While HEC may affect individual farmers in a community differently depending on the location of their crop fields in regards to a village and forest boundary, crop protection efforts are more effective when they can be accomplished cooperatively as all community members stand to benefit from such actions.

Between communities and government

The importance of having integrated conservation and development projects to help local communities improve their livelihoods is essential. Awareness campaigns should inform local communities about the need for such action and the benefits that it brings. Community awareness of and support for these types of projects helps to put pressure on the government to commit and act on them. Governments should also involve local communities in the HEC evaluation and mitigation process, so that their problems are better understood and so that suitable short-term and long-term HEC mitigation strategies are developed. Assistance should be provided to develop and apply local and novel methods of HEC mitigation, and, at the same time, local communities should be encouraged to solve their own problems.

Between NGOs and government

NGOs can support government agencies by providing technical help to the government in evaluating land-use situations and formulating effective policies and strategies that will address habitat loss and HEC mitigation. There is a need for NGOs to increase public awareness so that there is effective advocacy and lobbying to get governments to involve the wildlife and environmental sectors in the land use planning processes and stop further habitat loss. NGOs can also provide technical support for the implementation and monitoring of government efforts to manage HEC.

► Lack of resources

Most Asian elephant range countries are developing countries with limited financial resources to commit to conservation, so funds remain a major constraint in conserving elephants. With governments focusing primarily on development, conservation often takes a back seat. Political will and public support for conservation can be generated by making people aware of the ecosystem services (watershed, moderating climate, etc.) provided by elephant habitats. Advocacy and building awareness both within and outside Asian elephant range countries is essential for generating increased support for protecting elephants and their habitats. Given the range of problems associated with elephant conservation, it becomes very important that scientifically sound conservation and management strategies be adopted. However, management capacity and the institutional strength of government agencies mandated with wildlife conservation need to be improved as well. One of the major limitations is the lack of good data on wild Asian elephants, their ecology, ranging behavior, and population dynamics. In addition, the failure to use existing information in planning for conservation, HEC mitigation, and development hinders elephant conservation in Asia.

► Apathy and/or resignation

Despite the awareness that the primary cause of HEC is habitat loss and fragmentation these activities continue. This not only brings elephants from new areas into conflict, but it is also bringing existing problem elephants into greater conflict. This points to either a lack of proper understanding or lack of political will to stop further habitat loss and fragmentation. This could be tackled by creating awareness among other stakeholders (communities, agro-forestry companies) about the need for land use planning that takes into account the needs of the elephants and of the people, and the benefits to them of such plans. The communities then become part of the pressure group to get the government to act on such plans and stop habitat loss.

Apathy is a major factor for the failure of many HEC mitigation efforts, mainly because poor selection and application of HEC mitigation tools leads to a sense of resignation from the farmers and authorities when the tools are unsuccessful. The ensuing apathy also ensures that no monitoring or corrective actions are implemented in cases of failure.

► Corruption

Corruption at all levels of society, in and out of government, can significantly undermine the effectiveness of conservation work. Generally governments do not place a high priority on policies in support of conservation, law enforcement is not well supported, and staff may be poorly compensated. Such factors create a situation where HEC management work can be susceptible to questionable financial practices. Corruption is an important factor in the failure of the proper application of a suitable tool and/or of the effective implementation of tools to mitigate HEC.

► Are there implementable solutions?

Human-elephant conflict is a problem that has existed for a long time, although in many areas around Asia the severity is increasing. HEC is very complex and no ultimate solution is available. One cannot understand the seriousness of the problem unless it is personally experienced at some level, and as long as humans and elephants share space the problem will remain. Even though governments and stakeholders such as communities, private companies, and NGOs have been trying to cope with the problem and protect both humans and elephants, sometimes HEC is unmanageable. Therefore, flexible attitudes should be developed, and priorities should be established. Only by looking at HEC comprehensively can change be effected.

Local community awareness program in Nepal. *Photo by Heidi S. Riddle*

Key Considerations

Management Issues

- The major reasons for the failure of HEC management measures have been due to human factors.
- Capacity building has to be an integral and basic component of any attempt to address HEC.
- The biggest hurdle to effective HEC management is that people have not been informed about how to deal with conflict and expect the government to resolve HEC problems.
- Efforts should be made to increase public awareness about HEC issues so that advocacy and lobbying ensure government commitment and involvement in making land use planning an integral part of policy on elephant conservation and HEC mitigation.
- Lack of cooperation, lack of resources, apathy, and corruption are major constraints in HEC mitigation and need to be addressed in a serious manner through awareness and capacity building.
- The failure to use existing information in planning for conservation, HEC mitigation, and development hinders elephant conservation in Asia.

SECTION 6: Assessing and Monitoring Human-Elephant Conflict Mitigation

Evaluating and monitoring techniques and protocols are an important part of HEC mitigation. In this section suggestions are provided regarding the information needed to evaluate the types of HEC and identify the solutions needed in order to ensure an adaptive approach to HEC mitigation. Monitoring is not only about monitoring the impacts of HEC, but also about monitoring government and civil society work on HEC management so that participatory and flexible methods are considered.

Assessing HEC Mitigation Needs

The approach to elephant conservation and HEC mitigation needs to be holistic and integrated. As a first step, each Asian elephant range country should develop, and periodically review, a clear and well defined National Policy addressing elephant conservation and HEC management. Governments may need guidance and support from the conservation and scientific community to develop such a policy. At a minimum, a well-defined policy will commit the government and conservationists to a specific course of action, and move away from ad hoc HEC management. A policy can only be implemented successfully if it is backed by a well thought-out and practical strategy that addresses all relevant issues. There is also a need for a legal and regulatory framework that supports vertical and horizontal integration. Vertical integration addresses inter- and intra-departmental operations and coordinating national, provincial or state, and district level administrations. Horizontal integration addresses the need for coordinated action by linking various government departments, private sector agencies, NGOs, communities, etc. into a single entity working to address HEC management.

Along with a National Policy there is a need to establish well designed and cost effective monitoring schemes to produce quantitative data on the impact of the various HEC mitigation programs currently being implemented in Asia. An analytical process should be developed allowing the identification of all causes and factors that need to be considered when deciding on the best HEC mitigation method(s) suitable for a given site. A monitoring mechanism should be established to oversee the implementation of any actions. The policy should aim for systematic and sustained application of HEC management techniques whose efficacy has been tested through monitoring. There should also be recognition that HEC management in reaction to crisis situations with methods whose efficacy has not been tested does not resolve HEC.

When assessing HEC mitigation needs in a given area, it is crucial to review data on certain important issues prior to deciding on a course of action. Each issue has to be critically assessed, as planning will need to consider the benefits and challenges posed by the various issues. Any HEC management action also needs to include monitoring. The mitigation of HEC will be more effective if proper evaluation skills are used to identify and monitor the specific HEC situation, and an adaptive approach is taken.

Important information needed to assess site-specific HEC mitigation includes:

- Data regarding elephants (i.e. habitat, population, behavior, etc.);
- Information about the interface;
- Type of HEC situation;
- Assessment of HEC mitigation methods currently used;
- Assessment of the intensity of HEC in that area and how local people are affected; and
- Implications of HEC for elephant conservation need to be addressed.

When assessing HEC mitigation needs, critical consideration needs to be given to the following factors which have led to the failure of effectively mitigating HEC in Asia:

- The root cause (habitat loss) for HEC has not been stopped;
- Absence of a clear policy and strategy to deal with HEC;
- An ad hoc approach to HEC resulting in knee-jerk responses to crisis situations rather than a well-planned long-term strategy to resolve the problem on a lasting basis;
- Improper application of HEC mitigation methods;
- Absence or poor involvement of stakeholders, especially local communities;
- Absence of monitoring that would allow an adaptive approach to HEC management;
- Absence of a scientific approach due to a poor understanding of elephant biology and the use of simplistic assumptions that may be incorrect;
- Absence of an understanding or assessment of the scalability and long-term applicability of HEC mitigation measures; and
- Absence of sustained application and monitoring of HEC mitigation strategies.

► Elephant habitat, population, and behavior related issues

When planning HEC mitigation there is generally a lack of baseline data on elephant habitat, population, and behavior which should provide the scientific basis for management decisions. This hinders proper assessment of HEC situations and hence does not allow effective planning. While some data on the economic loss due to HEC is available most of the other data is inadequate. Even the limited information is generally not considered when formulating conservation and HEC mitigation strategies; this can seriously hamper both HEC mitigation planning and also elephant conservation within the landscape. It is also important to prioritize the needed collection of data in order to have a better understanding of each HEC situation. While some of the data may be urgently required for site specific HEC management, other data may not be so urgently needed and may be more useful to long-term planning and monitoring.

Land use planning is central to HEC management. A clear and well-defined policy addressing land-use at the national and local levels is key. Additionally, basic information on elephant distribution and ranging, habitat quality and quantity, and behavioral ecology of elephants is important for HEC management planning and for prioritizing elephant populations and conservation actions across Asia. A better

Oil palm plantation bordering a protected area in Sumatra, Indonesia. *Photo by Heidi S. Riddle*

understanding of elephant home range sizes, ecology, and densities in different vegetation types would be very useful. If HEC mitigation is to be done in a scientific and professional manner, the issue of small isolated elephant populations with no long-term conservation value also needs to be addressed. There may be a need for more areas to be managed as PAs or MERs to help conserve elephants and minimize HEC; in such cases detailed ecological studies should be carried out to properly support PA and HEC management planning. In areas where the habitat is severely degraded, direct intervention (habitat improvement/enrichment) may be necessary to reduce HEC.

► Interface related issues

The interface is the common boundary between elephant and human use areas *(See Section 2)*. The interface area and the perimeter length have implications for HEC mitigation at the landscape and at the village level. Poor interface areas lead to difficult application of HEC mitigation methods or make applying them expensive and prone to failure. Identifying and creating boundaries in areas that have been fragmented with no clear definition of margins is critical for HEC management.

Clear boundaries between elephant habitat and human use areas are more conducive to applying effective crop protection methods and managing HEC as they lend themselves to the installation of elephant proof barriers, the manpower required to guard the boundary is reduced, and the costs associated with crop protection are reduced as the length of the interface area is diminished. Diffuse boundaries are not conducive to effective HEC mitigation measures involving barriers or fixed deterrents as there is no clear boundary where the barrier can be implemented.

In addition to the type of interface, the length of the interface area (perimeter length of human use area or elephant habitat) can influence the intensity of HEC and its management. Convoluted

boundaries with lengthy perimeters will increase the costs of applying HEC mitigation measures, increase chances of conflict, and increase the likelihood of elephants encountering the boundary. Shorter perimeters reduce the cost of protecting the interface, and minimize the number of affected elephants.

Changing the interface so that HEC is minimized locally can be done by the use of alternate crops or by changing the land use. Damage can be minimized by growing crops that are not preferred elephant food. However even when alternate crops are not eaten by elephants they may get trampled by elephants crossing through the agricultural areas, and the revenue loss is just as significant to the farmer. Planting alternate crops as buffer between elephants and preferred crops may not have a significant effect unless the buffer crop zone is broad enough (several km.) to prevent elephants from easily reaching the preferred crops. Minimizing HEC locally can also be accomplished by changing the use of the land. Modifying land use from agricultural to non-agricultural may help to reduce the frequency of elephants entering into the area.

Removing the interface would eliminate the common boundary between humans or elephants that share a same area. This is done either by removing people or removing elephants. Shifting agriculture/ settlements out or away from elephant habitat is a possible solution in select cases, and has been done in some range countries in Asia. Removing elephants can take the form of a) removal of a few select problem animals; b) removal of an entire population; c) removal of a few elephants to manage the elephant population in a specific area in a manner that suits conservation and HEC management.

► Type of HEC situation related issues

HEC mitigation work is at a disadvantage when there is no baseline data that supports decision making. Quantitative data on HEC would allow sites to prioritize for HEC mitigation activities and allow monitoring the impact of management actions. There are situations that bring their own set of problems and are significant enough to warrant being addressed when HEC management is considered. These situations result in the creation of land use that often facilitates HEC and undermines elephant conservation in those areas. In areas where there is shifting cultivation, a technique known as slash-and-burn is used primarily for subsistence farming in many Asian countries. This system involves clearing a piece of land by setting fire or clear felling, and using the area for growing crops. This type of cultivation is detrimental to maintaining adequate forest habitat for elephants and significantly contributes to fragmenting and degrading existing habitat. Furthermore, the burning or clear felling of forested areas drives elephants into these newly existing human use areas and significant HEC ensues. Monoculture plantations (i.e. rubber, pulp wood, tea, oil palm, etc.) convert large areas of forests into areas that elephants are no longer able to fully use. While elephants may still use the plantation areas to some degree, either for shade or to feed on grasses growing in these areas, their presence increases the opportunities of conflict with plantation laborers. Additionally the elephants may damage plantation trees, leading to some economic loss for plantation managers.

Identifying the causes of habitat conversion and increased HEC, defining the impact on elephants and implications for HEC will assist in identifying and developing possible solutions that could be used to alleviate any adverse effect on elephants.

► Assessing HEC mitigation methods currently used

Assessing HEC mitigation requires adequate and objective monitoring of the measures used in any given situation to determine the benefits or failures. Equally important is the need to evaluate if any

achievements in conflict reduction are short- or long-term. Currently, mitigating HEC through the use of barriers (i.e. trenches, electric fences, etc.), or by driving elephants out of human use areas consumes a significant part of elephant conservation budgets. However, the documentation of what these investments have achieved in the form of possibly reduced conflicts (frequency of crop raiding, loss of human lives), and/or reduced numbers of compensation claims is inadequate to understand which methods may produce a more worthwhile investment, both for short-term and long-term HEC mitigation planning. Systematically recording and sharing data on these aspects would greatly assist in the decision making process when evaluating the utility of HEC management interventions in economic and social terms.

► Assessing HEC intensity and its implication to the affected people

It is important to measure and understand the frequency and area of damage in any given site prior to developing a site specific HEC mitigation measure. Conflicts with elephants vary in physical intensity from site to site, and the people directly affected may not consider differences in frequency and area of damage when they lose crops or property. In some regions elephants are prone to entering human use areas often, and the damage caused during each incursion varies from mild to severe. In other situations elephants may enter human use areas infrequently, but they may cause a high level of damage each time. If the frequency of raiding is low (i.e. seasonal only) it may not be worth using resources to protect crops daily, but rather to focus those resources for protection only during the time when elephants are known to raid.

HEC negatively impacts human well-being. While the immediate and most visible impacts are loss of crops, property damage, physical injury or loss of life to people sharing space with elephants, there is little information about the less visible impacts of HEC, particularly on the well-being of rural, agricultural communities. Assessing these less visible impacts will assist in understanding local communities' perception of the intensity of HEC and will assist in developing HEC management measures that consider the human factor.. Overall in Asia the cultural tolerance to HEC is eroding. People perceive elephant caused damage as being the most problematic, even though elephants are responsible for a small proportion of crop loss when compared to other causes such as natural disasters or pests (rodents, insects, birds, etc.). However elephants also cause injury and loss of human life so the fear of HEC is very real.

► Conservation implications of HEC

It is important to assess how HEC mitigation efforts impact the affected elephants as well as the impact on the broader issue of elephant conservation in Asia. There is an urgent need for an umbrella strategy on the use of HEC mitigation as a conservation tool for Asian elephants; these are large mammals with habitat requirements of 200-600 km^2, therefore the HEC mitigation impact should also be viewed from the elephant population level (e.g. PAs or landscapes) rather than only at the site level (e.g. villages), even if individual projects are implemented at various geographic scales.

Many of the problems of HEC come from the fact that initial development planning did not take elephants (and the problems they can create) into account. The ongoing and increasing HEC is the consequence of not having a clear policy supported by a well thought out and practical strategy to deal with elephant conservation and HEC mitigation. For example, all Asian elephant range countries are developing infrastructural projects (e.g. Trans-Asian highway project, various hydro-

power projects, etc.) that will significantly increase HEC. Costing and including HEC mitigation options at the planning stage of these large infrastructural projects will lead to economic and conservation gains, and the involvement of multilateral agencies can help mainstream HEC mitigation options via their investment in the countries.

With rapidly dwindling habitat, the HEC situation throughout Asia is getting much more severe, leading to an increase in property damage and loss of life. The ongoing public demand for government action and the increase in retaliatory killings of elephants by villagers indicate that the situation is desperate and is likely to get out of control if action is not taken. When improperly managed, HEC leads to a general antagonism towards elephants, thereby seriously hindering all conservation efforts in the region.

Evaluating HEC Mitigation Efforts

HEC mitigation strategies are either not well planned or improperly applied, often resulting in failures. A lack of information on habitats, populations, and the behavioral ecology of elephants and implications for HEC mitigation undermine management efforts. Policies to address HEC mitigation are either absent or inadequate. An adaptive strategy is needed so that HEC management efforts can be evaluated and different approaches are used to mitigate HEC in different situations.

The focus of evaluation should be to apply adaptive management and implementation of best practices of HEC mitigation efforts through monitoring and evaluation management actions.

Best practices can be defined as HEC mitigation efforts that:

- Identify the most appropriate tools for HEC mitigation in a holistic manner through systematic assessment of HEC;
- Apply the selected HEC mitigation tools in a proper and systematic manner;
- Monitor the HEC mitigation effort to measure the success of the method (reduction in HEC); and
- Take an adaptive approach that allows change of tools, efforts, approaches, etc. whenever indicated by the monitoring effort.

► Evaluation of the process used to identify mitigation methods

There is a need to shift to realistic and practicable HEC management based on good data. A comprehensive assessment of the HEC situation is needed so as to identify the most appropriate mitigation methods for a particular site. Effective and suitable HEC mitigation methods should be considered, and a standardized HEC damage reporting system and a code of practice for HEC mitigation should be developed. Data collection and evaluation protocols should also be considered. HEC mitigation efforts need to be monitored and measured to evaluate success and failure in a clearly quantifiable way. Ultimately success needs to be evaluated in terms of its implications for managing HEC on a long-term basis and for elephant conservation.

There is a need to facilitate information-sharing about HEC mitigation and increase awareness and

knowledge among policy makers and local people. A process of cooperation among various agencies and stakeholders to effectively manage HEC should be initiated, and community based organizations should be institutionalized to empower local institutes to deal with HEC. Decision making should be a transparent process and multiple stakeholders should be involved in the HEC mitigation decision making process At the local level, steering committees could be set up to manage, monitor, and implement any HEC mitigation proposals in their area. Capacity and resource needs at local levels also need to be considered. Further it would be helpful to share information about HEC mitigation more broadly, among and within range countries, for example by setting up effective experience-sharing forums and a common and easily accessible database.

► Assessment of methods used for stopping or reversing HEC

The importance of stopping habitat loss and degradation, and restoring degraded habitat has been discussed earlier *(See Section 2)*. Stopping or regulating habitat loss requires cross sectoral linkages between various government agencies and long term land use planning. Including an elephant-specific "Environmental Impact Assessment" (EIA) in land-use planning may stop poorly planned development and can benefit people and elephants. When managing habitat it is also crucial to gain national support for such actions, and to provide adequate time (minimum 5 years) to implement habitat improvement projects.

Baseline data on HEC is required to effectively address HEC on a landscape level. This data helps to prioritize actions as well as design effective crop protection measures. Data should be produced from mapping HEC within a landscape; the distribution of the elephant population within that landscape should also be mapped. As a significant part of the elephant population and habitat lies outside the PA network throughout Asia, establishing zones known as "Managed Elephant Ranges" (MERs) *(see Section 2)* can help address the need to have large areas managed for elephants without the need to create new or larger PAs. Connecting fragmented habitat patches by identifying and protecting corridors is critical to maintain adequate range for elephants and reduce HEC.

► Assessment of methods used for containing HEC

Containing HEC falls generally into the categories of guarding and barriers; these two broad categories can be used alone or together (*See Section 3*). To assess methods used for containing HEC requires at the outset an understanding of the operating principles of these two basic measures.

The method of crop protection would depend on several important issues:

- existing natural habitat (extent and quality);
- the elephant population in the area;
- the frequency of crop raiding;
- the type of interface area; and
- the elephants that are coming into conflict (male or female).

Planning a guarding strategy for crop protection requires understanding the type of crop raiding that is occurring in the specific area. Guarding is used to augment other crop protection tools and should involve regular changes in guarding tools so that elephants do not become habituated. When assessing barriers, several issues need to be considered: design flaws in barriers, fences not placed at the habitat boundary, gaps in the fences, etc. all of which have been causes for their

failure. Structural flaws which result in fence routes not being cleared of vegetation, poor quality construction, inadequate power, etc. are also causes for failure. When identifying a suitable deterrent for a specific HEC site it is imperative to understand the limitations and suitability of the tool itself. Poorly designed planning and implementation are major causes for the failure of HEC deterrent tools. It is important to work with communities to properly layout HEC deterrents or barriers and address jurisdictional issues. When using barriers for HEC it is critical to consider how these barriers will affect elephants' ranging and resource use, so as not escalate HEC instead of mitigating it.

There is also a need to identify novel methods for HEC mitigation, and to involve local communities in the development of such methods. Local community based efforts at HEC mitigation should be encouraged and supported. Further research would be required to test the feasibility of using alternate methods of HEC mitigation (i.e. the use of chillies as a low cost means of crop protection, use of Acacia plantations as a buffer, the use of alternate crops, etc.).

Monitoring HEC mitigation measures put in place by a proposed project is important for effective implementation of the project. The absence of sustained application, poor maintenance, and poor monitoring has been a major reason for the failure to effectively contain HEC.

► Assessment of compensatory mechanisms

In general there are two different types of compensatory mechanisms in Asian elephant rage countries *(See Section 4)*. Compensation is either through direct support which occurs when people receive payment for injury, loss of life, property and/or crop damage as a result of HEC or it is through indirect support that may be in the form of developing alternate incomes, improving existing incomes, or improving livelihoods to cover for losses due to HEC.

Compensation is a complex issue for addressing losses caused by HEC; insurance is still a novel idea to address the same issues and requires further investigation in Asian elephant range countries. As with all HEC mitigation tools, a periodic review and assessment process is needed to identify if and when the use of compensation and/or insurance schemes are suitable. It would be helpful to start the assessment by reviewing existing compensation and insurance schemes to develop a structure for potentially applying and monitoring such schemes for HEC losses in Asia.

Assessments of compensation should include whether HEC relief schemes offer monetary support or offer other forms of support such as food and/or livestock, the provision of aid to fix or replace water supplies and/or food storage facilities and/or fences, etc. Evaluating the effectiveness of the various forms of support is important.

A review process is needed to identify if and when the use of indirect support schemes is suitable. Existing programs should be studied to develop a structure for potentially applying and monitoring such schemes in Asia. Assessments and help identifying or developing markets for products grown or produced through indirect support schemes are also essential.

There is a need for quantifiable data on the income from such programs, linkage to reduced HEC, change in peoples' attitudes and practices, and tolerance for elephants. To be effective long-term, such schemes should be implemented and monitored in a collaborative and transparent manner between local communities and government agencies.

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