Tackling routes to coexistence

Human-elephant conflict in sub-Saharan Africa

Study commissioned by
GIZ Partnership against Poaching and Illegal Wildlife Trade

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March 2019

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List of abbreviations

AEAP	African Elephant Action Plan
AfESG	African Elephant Specialist Group
CBC	Community-based conservation
CMS	Convention on Migratory Species
CBNRM	Community Based Natural Resource Management
COMIFAC	Central African Forest Commission
CSL	Conservation South Luangwa
DAS	Domain Awareness System
DNPW	Department of National Parks and Wildlife
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Development Agency)
GMA	Game Management Areas
HEC	Human-elephant conflict
HWC	Human-wildlife conflict
IUCN	International Union for Conservation of Nature
KAZA	Kavango-Zambezi Transfrontier Conservation Area
MET	Ministry of Environment and Tourism/Namibia
NGO	Non-governmental organisation
NP	National Park
PE	Problem elephant
PEC	Problem elephant control
PA	Protected Area
RRT	Rapid Response Team
SADC	Southern African Development Community
SMART	Spatial Monitoring and Reporting Tool
STE	Save the Elephants
UVA	Unmanned Aerial Vehicle
WMA	Wildlife Management Areas
WWF	World Wide Fund for Nature

Acknowledgements

This study was commissioned by the “Partnership against Poaching and Illegal Wildlife Trade in Africa and Asia”, a project implemented by GIZ on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The partnership operates along the entire illegal trade chain in ivory and rhinoceros horn from the countries of origin in Africa to the consumers. It follows the main objective to improve the inter-sectoral, cross-border and trans-continental fight against poaching and illegal trade in ivory and rhino-horn. The topic of human-elephant conflict is seen as relevant to this field as well, as it can strongly influence the perception of local farming communities and their attitudes towards elephants and their protection.

Conducting this review would not have been possible without the valuable input of many people, whom I would like to thank sincerely. I would like to acknowledge 23 interviewees of different projects all across the African continent to contribute with sharing their multiple and extensive experiences and knowledge on human-elephant conflict and coexistence with me. About 40 hours of interviews were conducted, some with a length of up to 3 hours. Thank you so much for allocating your precious time to this study.

Note of the author:

The study covers a large array of different topics. Technical terms might have been used in a broader sense, as different stakeholders often use them with slightly different meanings. The main focus was to ensure comprehensibility and coherence.

If you identify any mistakes or have the feeling that information you provided is not reflected correctly/adequately, please get in touch with the author.

Executive summary

Human-wildlife conflict (HWC) is a highly complex issue, involving not only behavioural and ecological aspects of wildlife species but also social, cultural, political and economic levels. Understanding the complexity is essential for the identification of strategies and solutions leading to a long-term coexistence of people and wildlife. As elephants are a highly intelligent species and very adaptive, human-elephant conflict (HEC) is particularly difficult to mitigate. Strategies on the management of HEC need to take into consideration its complexity on all levels, closely monitor effects and changes and adapt management strategies accordingly.

Box 1: How to use this study

This study is based on a literature review of over 100 scientific papers and grey literature reports supplemented by 23 expert interviews (qualitative guideline-based technique). For those with short time budgets for reading, this executive summary gives an overview of the complexity of the topic. For this study six areas of operation were identified, which need to be addressed to achieve a long-term coexistence of people with elephants. These six areas of operation (monitoring, political, social, financial, technical and spatial levels) are marked with icons for easy identification. The executive summary refers to the respective chapters for further reading. The main study explains the context, benefits and limitations of different strategies within the six areas of operation. Benefits and challenges of each measure are summarized in table form at the end of each description. Blue boxes elaborate on important background information.

An introduction to HEC

Chapter 1 of this study introduces the African elephant (*Loxodonta africana*) and explains the background of HEC. Elephants are a highly social and intelligent species holding an important ecological role in the African savannas and forests. Due to massive poaching for its ivory the species is under threat and ranked as vulnerable by the IUCN Red List. Furthermore, the decline and fragmentation of habitat caused by ongoing conversion of wilderness areas into agricultural and industrial landscapes is a major threat to the African elephant. However, the conservation status of the species differs strongly among the 37 elephant range States.

Situations in which wildlife impacts humans negatively (physically, economically, or psychologically), and humans likewise negatively impact wildlife, are considered as HWC. This definition includes the interaction of species and people as well as underlying causes of conflict based on relationships between groups of people. When elephants damage crops and human properties or lives, losses can be substantial. If not appropriately responded to, this can easily influence the attitude towards the species and conservation issues in a negative way. On the other hand, elephants can suffer from retaliatory killings or being harmed during human activities to defend habitations or fields. Besides these direct losses intangible costs of living with elephants

and psychological stress make it difficult for people to develop tolerance of elephants living within their community.

With the end of the massive ivory crisis in the late 1990s elephant populations were slowly recovering and moving back into areas they had once populated. Many of these areas were now populated by people, who did not know how to coexist with elephants (anymore). The consequence was a drastic rise in HEC. This is important to understand, as a similar development may take place, when the current ivory crisis has been put to a halt. About 70% of the elephants' range is currently unprotected. Generally HEC can appear everywhere, where people and elephants are sharing the same landscape. In recent years it has been shown that elephants are feeding on cultivated crops even if the natural habitat provides sufficient forage. High nutritional value, the low natural defence and the easy access to cultivated crops makes them highly attractive to elephants.

It has to be understood that HEC actually is a conflict between people over elephants and over resources. To be able to achieve a long-lasting peaceful coexistence between elephants and people social and political aspects need to be taken more into the focus of HEC analysis and management. When analysing and designing HEC the different levels of conflict need to be taken into consideration. Underlying or deep-rooted conflict will not be solved through technical solutions (see chapter 1.5).

This study seeks to understand the current situation of HEC on the African continent and the role it plays for the conservation of this charismatic species. Thereby different ecological as well as cultural systems are taken into consideration. Measures to prevent or mitigate HEC are described and assessed regarding their potential for success or failure. Here not only technical measures, but also financial and indirect measures, are taken into consideration. The issue of HEC data collection and analysis is summarized in a special chapter.

HEC monitoring

As HEC monitoring plays an important role for evidence-based decision making chapter 2 has been dedicated to this topic. Wildlife authorities generally collect HEC data within a financial compensation framework or for monitoring purposes on paper. Government departments, however, are often facing difficulties in carrying out this assessment properly, due to manpower, technical or transportation constraints. HEC data collection on community level has been carried out successfully in Namibia's conservancies by game guards with simple paper forms and analysis by simple descriptive statistics. In Zambia HEC data collection is carried out by NGO staff on hand-helds, which allows quick data analysis and the production of maps. Despite these positive examples most countries and programmes on the African continent seem to be facing constraints. The lack of comprehensive and uniform HEC data collection decreases the support of management decisions and creates difficulties in defining sound and smart indicators for HEC mitigation programmes. A comprehensive HEC monitoring scheme should serve for a spatial and temporal analysis of HEC trends capturing the frequency and magnitude of different types of damage. It further should take into consideration the severity of a damage relative to the income situation as this influences the resilience of victims to HEC. As HEC includes both sides, elephants and people, it should further integrate the attitude of the victims. The combination of such HEC data with

elephant movement and occurrence as well as poaching data may give direction for future HEC management applications.

Political framework for HEC management

International and national framework documents involving HEC prevention and mitigation are presented in chapter 3.1. Here, focus is put on five strategic levels (political, social, financial, technical and spatial), which ideally should be combined for effective and long-term solutions to HEC. The most important international document in terms of elephant conservation and HEC management is the African Elephant Action Plan (AEAP). The AEAP is fully owned and managed by the African elephant range States, and outlines the actions that must be taken in order to effectively conserve elephants in Africa across their range, and the reduction of HEC is the third of eight objectives.

A diversity of international and multilateral elephant conservation agreements including HEC mitigation and action plans demonstrate a strong awareness and relevance of the topic. In dependence on the multilateral elephant conservation agreements, national elephant conservation strategies were developed. Clear political frameworks on national levels as well as their implementation in communities living with elephants is crucial for the success of long-term strategies.

Social strategies for HEC mitigation

Social strategies (chapter 3.2) include participatory and inclusive approaches, community outreach and education. As conflicts can only be resolved by the inclusion of all parties taking a role in that very conflict, the participation of stakeholders plays a vital role in HEC resolution. When working towards long-term solutions to HEC, it has to be understood that HEC is a conflict of people over wildlife and over the use of natural resources. Building up good working relationships and a basis of trust requires transparent governance and communication. Involving community groups and members and other stakeholders into an open dialogue with shared information is highly important. In general, meaningful local participation with clearly defined roles and strong community ownership of the process will lead to higher acceptance and tolerance of the conservation work. In terms of HEC management, NGOs often see themselves as a bridge between community and governmental authority. Limitations of such concepts are seen in short-term funding of NGOs, particularly by international organisations. Specifically designed educational activities and raising of awareness for the importance of elephant conservation are seen as crucial for the long-term coexistence between elephants and people. However, only a few programmes seem to work on this topic in a strategic way. If HEC programmes are to achieve long-term success for the safe coexistence of people and elephants, educational programmes need to be reviewed and objectively evaluated.

Financial strategies for HEC mitigation

Damage to crops, properties or lives caused by elephants are of economic relevance. As described in chapter 3.3, in case there are no benefits through the presence of elephants, the farming community will barely support conservation work, particularly those individuals carrying the costs of living with wildlife. Financial strategies to decrease HEC need to take into consideration a) offsetting the costs/losses by HEC and b) increasing benefits of living with wildlife.

The issue of financial compensation of wildlife damage is discussed controversially, and governmental compensation schemes are rarely found on the African continent. Long waiting times, difficult application process (particularly for people with a low level of education) and low compensation payments are frequently heard points of criticism in areas where compensation schemes do exist. Community-based insurance schemes are generally based on revolving funds, which ideally are filled by income generated through the presence of wildlife. Funding agencies can also play a vital role in building up such funds. To design any sustainable and equitable compensation scheme calculations need to be based on accurate and realistic damage data.

Furthermore, revenue sharing concepts were developed in protected areas (PAs), based on the assumption that the presence of wildlife can create enough income for a community to bear the costs of coexistence. A common concept is that income generated by PAs (e.g. through entrance fees) is partly used to contribute to community management structures. Although these concepts lead to a positive direction, shares for communities often are insufficient and in case of governance constraints can easily be misused. If, however, used for community development projects, losses through elephants, which occur on an individual level, are not settled. Here, market-based strategies benefitting individuals are seen as an important part of financial development schemes. Developing economic strategies for benefits on an individual level, e.g. through alternatives to farm-based activities, can increase individual resilience.

Technical strategies for HEC mitigation

Since the 1990s HEC was studied intensively and with a focus on empirical work and understanding the causes of HEC. A series of mitigation measures was developed, sound scientific testing, however, was often missing. Many mitigation measures are found to have worked in one area/project, but not the other. There probably is hardly any field of conservation that harbours so many rumours, stories and beliefs like the field of HEC mitigation. NGOs are desperately searching for the strategy to take and the tool to use, inventing the wheel over and over again. After 30 years of working on HEC, governmental and non-governmental organisations, research institutions and local communities are still far from having found satisfying solutions.

In chapter 3.4 traditional and modern techniques to prevent or mitigate damages by elephants are described. As elephants have a strong capacity to learn, they can easily adapt to mitigation strategies and habituate to deterrents. Furthermore, the implementation of technical strategies may differ with regard to ecological and cultural context. For this reason, every technical strategy has its limitations and the circumstances under which they work or not, have to be taken into consideration. It is crucial to understand that the one measure to solve HEC does not exist. A combination of short-

term and long-term measures needs to be designed into a well-thought-out strategy, which allows adjustment and flexibility. Ad-hoc activities to soothe high levels of crop and/or property damage have to be distinguished from strategies to decrease crop and/or property damage in the long term.

Exclusionary methods, such as electric fences or trenches, probably are the most well-known technical measures to separate elephants and people. Placed around a protected area they bear the potential of keeping elephants in their natural habitat and out of human dominated landscapes. At the same time fences keep people and their livestock out of the protected areas. Fences decrease the movement of wildlife and result in high costs for population management. Furthermore, maintenance costs and labour are high, so that many fencing projects of the past have failed, as budgets did not take into consideration maintenance. Mobile electric fences can also be set up around habitations or farming areas, whereby monitoring of maintenance and usage is crucial. If not well maintained fences can easily be broken down by elephants through pushing poles, snapping electric lines with their tusks or felling trees over the fences.

When exposed to acoustic, visual or olfactory deterrents, elephants should develop fear and respond with flight. Loud sounds, yelling and drumming or fire crackers are often used acoustic deterrents, visual deterrents e.g. are lights, reflecting or moving objects, and olfactory deterrents may be created by burning dried chilli. Ideally, such elephants should learn to avoid areas protected with deterrents, resulting in a long-term protective effect. To achieve this, a deterrence strategy needs thorough planning and consequent implementation, and the risk of habituation of elephants against a deterrent has to be taken seriously. If an elephant is continuously confronted with a deterrent which is unpleasant but not life threatening, and at the same time manages to gain a positive response to its behaviour through feeding, the feeding success will outweigh the deterrent effect of the measure (positive enforcement).

Deterrent fences are low-cost physical barriers, which are supplemented with some deterrent measures to make them more effective against elephants. Metal strip fences are wire fences which light weight, moving metal materials are attached.

All fences need proper maintenance and daily monitoring, and the use of wooden poles may cause challenges due to availability and termites. Chilli fences combine the physical barrier with an olfactory repellent. While such fences have been found to be effective in many areas, they have been found ineffective in others. As for many crop damage prevention and mitigation tools used against elephants, proper maintenance of the measure is highly important and success may vary, depending on the habituation level of individual elephants or groups. Beehive fences consist of a fence onto which beehives are attached. The hives are naturally populated by wild honey bees. Once elephants try to enter through the fence, bees will start buzzing in the hives. This buzzing sound deters elephants. Deterrent effects depend on occupation rates of hives with bees. Coupled with market based strategies this deterrent bears the potential for income generation.

To avoid and overcome effects of habituation of elephants to specific measures the combination of deterrents is advised. The chilli bomber is a device combining acoustic, physic and olfactory deterrence. It is a simple device to shoot ping-pong balls filled with a chilli-oil extract against elephants. The ping-pong balls need to be fired with strong force, so that they will break when hitting its skin. The chilli bombers can be produced on site and used by trained community

members. The strategic community based guarding approach involves multiple deterrent measures and improves the traditional guarding practice of local farmers. Therefore, a common protection line, to which all guarding efforts are shifted, must be defined. Thus the complete protection of a whole farming block can be achieved through the efforts of the whole community of farmers cultivating a plot of land in a specific area.

Unmanned aerial vehicles (UAVs) can be used as modern combined deterrents to chase away elephants from the air. Operation needs to be conducted by skilled and trained UAV pilots, for example by members of rapid HEC response teams. Such trained experts on driving away elephants should be employed by governmental or non-governmental organisations.

All measures described above are measures to protect highly attractive crops or other food sources from elephants. As feeding preference of elephants on staple crops or other readily available food on farmland and villages will persist, such measures will always be cost and labour intensive. Decreasing the attractiveness of farms and villages for elephants, is another strategy to decrease the invasion of elephants into human dominated landscapes. This can be done by farming and marketing alternative crops, such as crops containing antifeedants or essential oils. These crops are unattractive to elephants, so they are not, or only to a very small extent, consumed. Such an avoidance has been demonstrated for African elephants for lemon grass, ginger, and garlic and for basil, citronella, chamomile, coriander, lemon grass, mint, and turmeric in Asian elephants. Furthermore, the attractiveness of villages for elephants can be reduced by storing edible products in elephant safe containers and dumping garbage in safe pits. Securing water points to decrease direct confrontation of people and elephants at water sources is another important measure; particularly in arid areas.

Reliable early warning systems, to detect elephants in a specific area and to warn farmers of their presence, are still under development. Organisations and institutions experiment with satellite tracking and geofencing, infrasound detection or other alarm systems. Despite great achievements in real-time tracking of elephants, we are still far from a “remote control” of elephants. The response to alarms still needs to be done manually and is risky, labour and cost intensive.

So called problem elephants, which have habituated to human presence, have learned where to find highly nutritious crops and have undone crop protection measures, may have to be removed from an area as a last resort. The translocation of such individuals is widely advocated by animal rights groups. However, this measure is highly cost intensive and translocated elephants often return to their original territory. Problem elephant control should be seen as the as last resort for elephants displaying very problematic behaviour. It, however, has to be taken into consideration that taking out one strongly habituated animal, will most probably result in a new elephant taking the niche.

Spatial management for human-elephant coexistence

When trying to find an answer to the general question on whether elephants and people can coexist, the spatial scale has to be taken into consideration (see chapter 3.5). As elephants are fond of staple crops, compete for water resources and may have learned to search for food in houses, a separation of people and farming activities at fine spatial scales is necessary to avoid damage. If solutions for a separation are found at these fine spatial scales, a coexistence at large spatial scale may become possible. The basic requirement for the separation at fine spatial scales is to understand the needs of elephants and the needs of people. Landscape connectivity is crucial for thriving elephant populations in many African landscapes. However, in case corridors are not properly protected and people living in its vicinity are not bound into economic strategies, education and HEC management programmes, there is a high risk that such areas become sinks for elephants. Successful land-use planning requires a professionally mediated process on a local scale. Land requirements need to be defined, development goals need to be agreed upon, and space for income generation and development needs to be defined. In such a process it is advisable to not only discuss the spatial requirements but also the details of usage.

The most important aspect about the spatial management of a safe landscape for people and elephants is its implementation on the ground. Truly participatory approaches are required to enable planning based on understanding and acceptance. The potential of a planning document will only unfold if all stakeholders of the region agree on it and contribute to its implementation.

Lessons learned

Interviews with 23 HEC managers of 12 African countries have given a deep insight into on the ground experiences around HEC and are summarized in chapter 4.1. Firstly, HEC is seen as a symptom, not a cause. Habitat loss and the arising competition for land and resources as well as other economic, political and social factors are seen as causes and drivers for HEC. In general it is understood that the problem of HEC cannot be wiped out completely, but it can be reduced to a tolerable level. Therefore, the involvement of local communities into HEC management in a strongly participatory way seems crucial for achieving a peaceful coexistence of people and elephants. As trust building takes time, participatory community work needs long-term presence; short-term and ad-hoc activities are bound to fail. Involving communities in HEC mitigation practically means relevant capacity building and equitable empowering.

The importance of maintaining contiguous habitat, securing access to water and protecting habitat connectivity is seen as the crucial aspect for elephants' survival in the future. Although research has achieved great results in the past, the need to learn more about spatial requirements of elephants in human dominated landscapes and understanding drivers of HEC is highlighted.

HEC management recommendations

Assuming the recent poaching crisis was solved, HEC is likely to rise again. Governmental and non-governmental institutions, therefore, need to get prepared, before farmers unnecessarily suffer big losses. Responsible institutions, however, are facing real constraints in terms of HEC mitigation strategies. In particular, they need to build up on capacity, skills, structure and training. Recommendations for HEC management are summarized in chapter 4.2 and focus on all political, social, financial, technical and spatial strategies as well as on HEC monitoring. High emphasis is put on a holistic approach to human-elephant coexistence. Focussing only on one aspect, e.g. technical measures, will not bring the desired outcomes and will not create sustainability. Organisations and institutions working on HEC need to take into consideration the full complexity of the subject. This requires interdisciplinary work for which skilled labour and experts are needed. If people and elephants shall still coexist in the year 2050 on the African continent, HEC prevention and mitigation needs to take a central role in elephant conservation programmes.

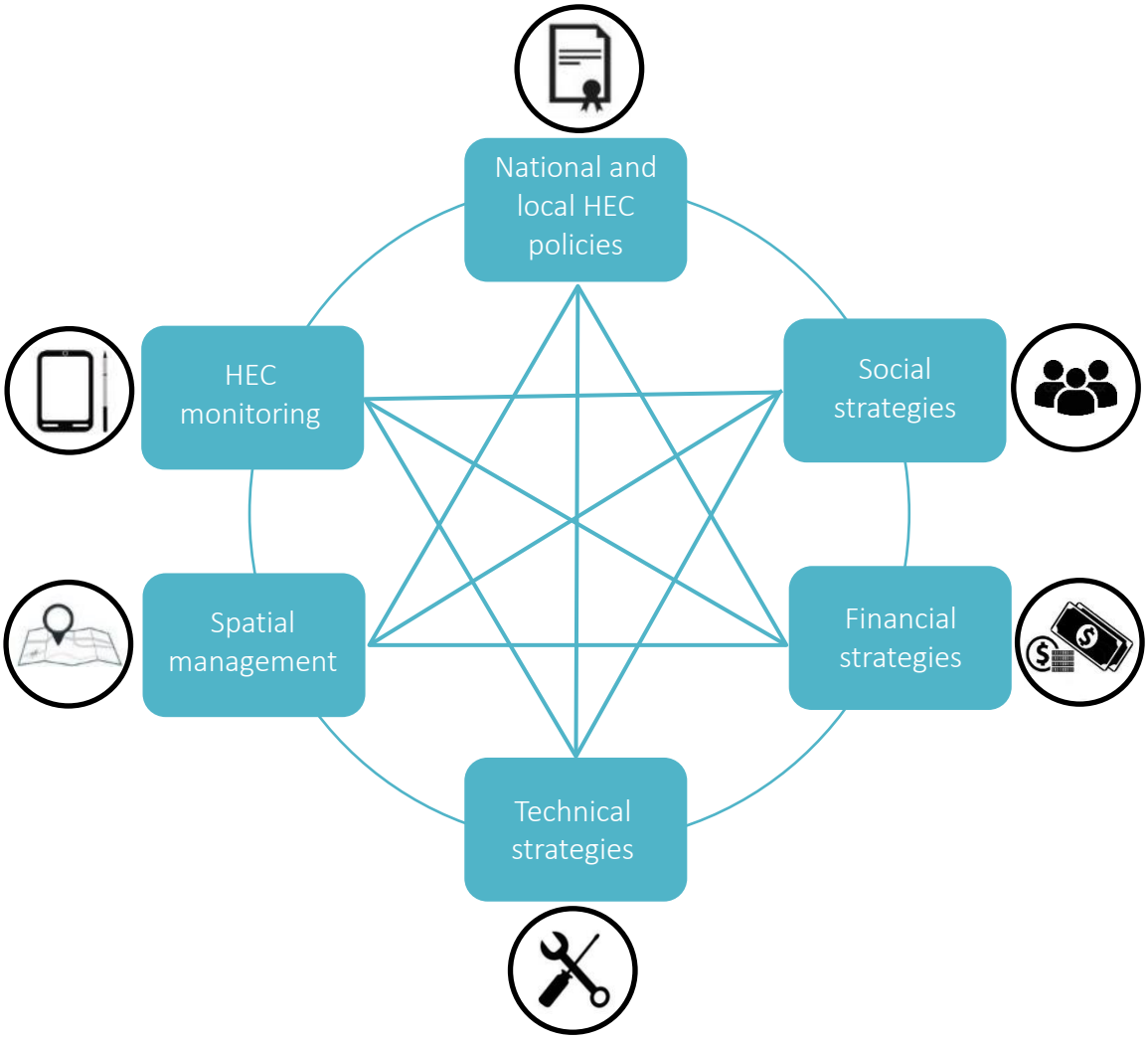

Figure 1: All areas of operation towards a safe coexistence between people and wildlife need to be considered to achieve long-term success.

Introduction

1 Introduction and Methods

1.1 African elephant: Conservation status and the role of HEC

The African elephant (*Loxodonta africana*) is not only the largest land living mammal, highly social and intelligent, it also holds an important ecological role in the African savannas and forests. Long-term research has demonstrated that elephants are shaping their surrounding landscapes through feeding activities, damaging tree canopies, uprooting small trees and shrubs, and dispersing seeds (Fritz 2017). For this reason wider biodiversity conservation goals require maintaining healthy populations of elephants throughout their ranges in Asia and Africa (Shaffer et al. 2019).

However, the elephants of the African continent are under threat and ranked as vulnerable by the IUCN Red List. Their conservation status differs strongly among the 37 elephants range states and among the different species that may exist. Besides the most numerous Savannah elephant (*L. africana africana*) preliminary genetic evidence suggests that the Forest elephant (*L. africana cyclotis*) is a separate species and a third species, the Western African elephant may also be described separately (Blanc 2008). At present, the African Elephant Specialist Group (AfESG) of the IUCN decided to remain with the classification of one species (*L. africana*) encompassing the two subspecies, until all required research has been finalized (AfESG 2003). For this reason, in this study the African elephant is treated as one species. In cases where the subspecies *L. a. cyclotis* is concerned, this will be particularly mentioned.

Since colonial times the African elephant has been hunted for its highly valued ivory. The elephant crisis of the late twentieth century had resulted in a ban on ivory trade and resulted in an increase in elephant populations, especially in southern and eastern African countries. Since the early 21st century a new poaching crisis has been observed (Thouless et al. 2016), putting the central and eastern elephant populations under massive threat and challenging conservation endeavours all over the continent.

Besides the direct killing of elephants, the decline and fragmentation of habitat caused by ongoing conversion of wilderness areas into agricultural and industrial landscapes and settlements is a major threat to the African elephant (Chase et al. 2016). The increase of human-elephant conflicts, resulting from negative interactions between people and the pachyderms is ranked as another important factor with negative consequences for the species' survival (Blanc 2008).

1.2 What does HEC mean?

Conflicts between people and elephants are a particular case of human-wildlife conflict (HWC). HWC generally refers to situations where wildlife impacts humans negatively (physically, economically, or psychologically), and where humans likewise negatively impact wildlife (Draheim et al. 2015). This definition includes the fact that interactions between wildlife and people can cause damage and costs to both sides and even result in disagreement between different groups of people (human-human conflicts) (Jacobsen and Linnell 2016). In many cases underlying conflict between conservation and other human interests are to be considered when analyzing and addressing human-wildlife interactions (Madden and McQuinn 2014, Redpath et al. 2014). Such

underlying factors driving HEC may be inequity of power, distrust due to weak governance or history, cultural beliefs and values etc. (Dickman 2010).

When elephants damage crops and human property or lives, this can easily influence the attitude towards the species and conservation issues in a negative way (Sukumar 1991, Kansky and Knight 2014). Especially in rural landscapes close to wilderness and conservation areas, where people and elephants compete for the same natural resources like water and space for cultivation, losses through wildlife can be substantial. As many of the world's 1.2 billion people who live on<$1.25 USD per day reside in African elephant range countries (Shaffer et al. 2019) such damage can have severe impact.

With their massive size and body weight of over three tons, African elephants can cause damage to crops just by walking through them, even without crop consumption. Although crop damage by elephants is less frequent than crop damage by rodents or insects on a large spatial scale (Stenseth et al. 2003, Oerke 2006, Bencin et al. 2016), the impact of just one elephant's damage for a single farmer can be catastrophic (Thirgood et al. 2005). Where elephant habitat has developed into exurban areas, elephants are found damaging houses and grain stores or feeding on garbage pits (Scrizzi et al. 2018, Gross et al. subm.-a). In arid habitats, such as in western Namibia, elephants are found to damage water pumps and installations in search for water (Hoole 2008). The most severe loss caused by elephants surely are direct accidents with people leading to injuries or even human fatalities.

On the other hand, elephants can suffer from human activities to defend habitations or fields, by being shot with arrows or muzzle loading guns, leading to wounds and a distressful death (Okello et al. 2014, Wharton 2014). Some countries allow the professional killing of elephants which are causing particularly high damage to people or their properties, or individuals that lost fear of humans and got habituated to feeding on crops or in villages. Such elephants exhibiting unusual behavior are defined as problem elephants and are professionally shot by wildlife authorities, following a framework on Problem Elephant Control (PEC). In Zimbabwe, between 2002 and 2006, more than five thousand cases of damage by elephants were recorded, of which around three thousand cases were attended to, resulting in 774 elephants being killed during subsequent PEC operations (Le Bel et al. 2011).

Picture 1 Crop damage by elephants on a field of maize, house damaged by an elephant in search for food, elephant caught and wounded in a wire snare (elephant was treated by a vet) in South Luangwa, Zambia. © Awely and Conservation South Luangwa

Besides these direct losses, hidden or intangible costs of living with elephants and psychological stress make it difficult to impossible for people to develop an appreciation for and tolerance of elephants living in their community (Jadhav and Barua 2012, Barua et al. 2013).

BOX 2: Background: Trends of African elephant populations

According to the African Elephant Status Report 2016 the elephant population is estimated at 415,000 to 570,000 individuals. This is approximately 118,000 less elephants compared to 2007 (Thouless et al. 2016). For the first time within the last 25 years this report shows a continental decline of the species.

The continental population of African elephants is living in 37 range countries in sub-Saharan Africa, whereby the population sizes and trends differ substantially from country to country. The southern African elephant populations are relatively stable, with the exception of Mozambique, where the population has massively declined since 2010. Botswana and Zimbabwe have the largest populations of African elephants and combined host 47% of the continental population (Thouless et al., 2016). In eastern Africa, particularly Tanzania, the populations are dramatically declining since 2010 or are more or less stable (Kenya). The central African forest-dwelling elephants *(Loxodonta africana cyclotis*), continue to decline at an alarming rate (Scholes and Mennell 2008). Generally, in the western African countries elephant populations are very low, except for the W-Arly-Pendjari Complex (Benin, Burkina Faso and Niger), where even an increase in population number was observed (Chase et al. 2016).

1.3 Development of HEC on the African continent

Crop and property damage by elephants are nothing new to the African continent. In fact both, humans and elephants evolved in Africa, having a 250 000-year history of cohabitation (Scholes and Mennell 2008). Scientific literature mainly emphasizes the increase in human population as a driver of HEC, as well as the resulting degradation of elephant habitat and of natural forage, reduced landscape connectivity and a significant decline of the elephant population relative to their historical range (Hoare 1999, Sitati et al. 2003). Due to that development elephants are forced into closer contact with people resulting in more frequent and severe competition between people and elephants over natural resources and space.

As we know today, particularly small scattered farms in elephant habitats are prone to crop damage (Graham et al. 2010). During times of small human populations with scattered farms in a wide landscape with large elephant populations, the pressure on farms must have been high, however, humans by then had been in the role of predators to elephants, before conservation law had to put elephants under protection. Elephants approaching farms were simply killed and the ivory was sold. In this regard, the ivory trade can be argued to have been a by-product of the competition between humans and elephants for land (Luxmoore 1991).

After the massive ivory crisis in the late 1990s, elephant populations were slowly recovering and moved back into areas they had once populated. However, many of these areas were then populated by people who did not know how to coexist with elephants (anymore). The consequence was a drastic rise in HEC. HEC and the development of HEC mitigation strategies received strong attention by that time (Hoare 2000b, Hoare 2012). A politically more involved farming population

and a rising criticism about exclusive conservation strategies has further fueled discontent and discussion (Adams and Hutton 2007).

In short, severe HEC on the African continent arose with two changes: a) the massive agricultural development enforced through colonialists (and the shifting from pastoralism to agriculture), and b) the protection status of elephants after a massive population decline through poaching.

Understanding the history of HEC is important, as a similar development may take place when the current ivory crisis has been put to a halt.

1.4 Where does HEC occur?

Conflicts between people and elephants generally arise where elephants are damaging people's farms or property or threatening their lives and where these issues are not addressed appropriately. Very generally said this is everywhere, where people and elephants share the same landscape. As generalist mega-herbivores, elephants consume a maximum of 150 kg of forage and 190 L of water daily. Meeting these basic needs requires a large foraging area to provide a variety of grasses, shrubs, and tree leaves, roots, and fruits. Depending on the habitat, African elephant family herds range over areas of 11–500 km^2 (Shannon et al. 2006). In recent years it has been shown that elephants are feeding on cultivated crops even if the natural habitat sufficiently provides forage (Gross et al. 2018). The high nutritional value, low natural defence capacity and easy access to cultivated crops makes them highly attractive to elephants (Rode et al. 2006, Von Hagen 2018). Particularly bulls are able to raise their reproduction success through feeding on crops (Chiyo et al. 2011, Chiyo et al. 2012). The conclusion, which still lacks clear scientific evidence, is that elephants are lured onto farmlands, particularly when staple crops are ripening (Gross et al. 2018), for feeding on crops, either facultative (because they can) or obligatory (due to lack of alternatives).

Elephants do not only populate and utilize protected areas. In fact, 70% of their range is currently unprotected. Although most large populations occur in protected areas (Chase et al. 2016), it is important to consider that the majority of the land African elephants are utilizing is communal and private land without a conservation status (Blanc 2008).

Furthermore, the protected areas (PAs) which elephants are populating do not only include national parks (without geographical overlap of people and elephants) but also and multi-use zones (e.g. Game Management Areas (GMA) or Wildlife Management Areas (WMA)), where people and elephants coexist. Those areas of overlap, where an interaction between elephants and people takes place, are prone to negative interactions, particularly when:

- highly attractive crops are farmed (nutrient-dense plants whose natural defences have been lost) (Van Hagen 2012),
- species are being driven out of their native habitats for anthropogenic usage,
- there is a close proximity of farms to boundaries of national parks or community ranches (Chiyo et al., 2005; Naughton-Treves & Treves, 2005; Sitati et al., 2003),
- corridors connecting protected areas lie outside of PAs, and/or
- other factors such as habitat loss, fragmentation, and climate change exacerbate the situation (Desai & Riddle, 2015; Karidozo & Osborn, 2015; Nelson et al., 2003).

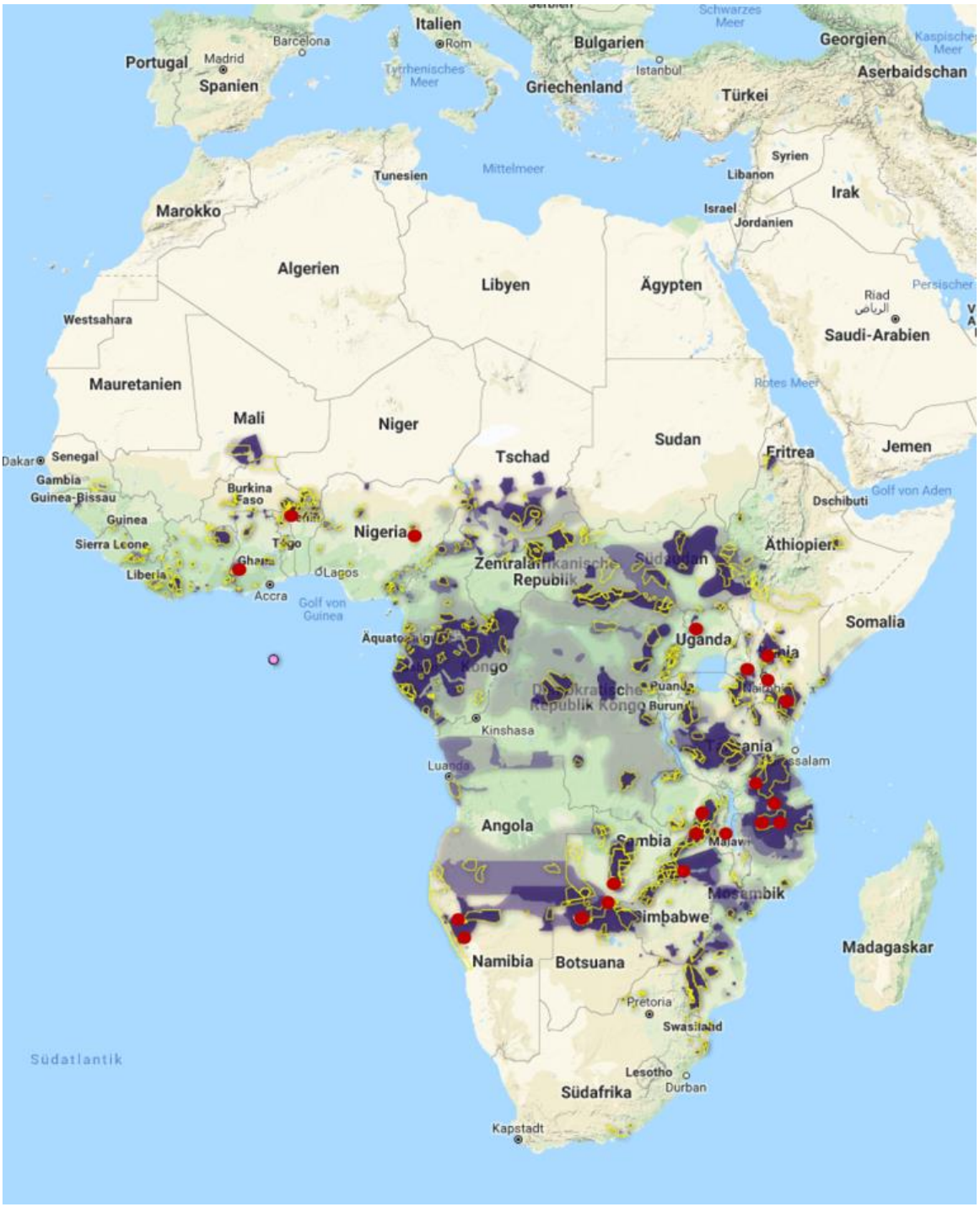

Figure 2 African Elephant Range 2012 and locations of interview participants (red dots). Dark purple: Known Range, Light Purple: possible range, Grey: Doubtful range, Yellow Protected areas. © 1995-2019 IUCN - The International Union for the Conservation of Nature

1.5 Addressing HEC

Finding solutions to HEC means reducing losses on both sides and bringing emotions down to a factual level. Today, much of the effort aimed at addressing HEC has focussed on prevention by keeping humans and elephants separated (Shaffer et al. 2019). Technical prevention and mitigation strategies are strongly dependant on site-specific factors and mostly offer short-term solutions, or they transfer risk from one place to somewhere else. These management approaches generally address the symptoms, rather than the underlying human dimensions fueling HEC, such as cultural values and decision-making concerning the use of resources.

It has to be understood that HEC actually is a conflict between people over elephants and over resources. To be able to achieve a long-lasting peaceful coexistence between elephants and people social and political aspects need to be taken more into the focus of HEC analysis and management.

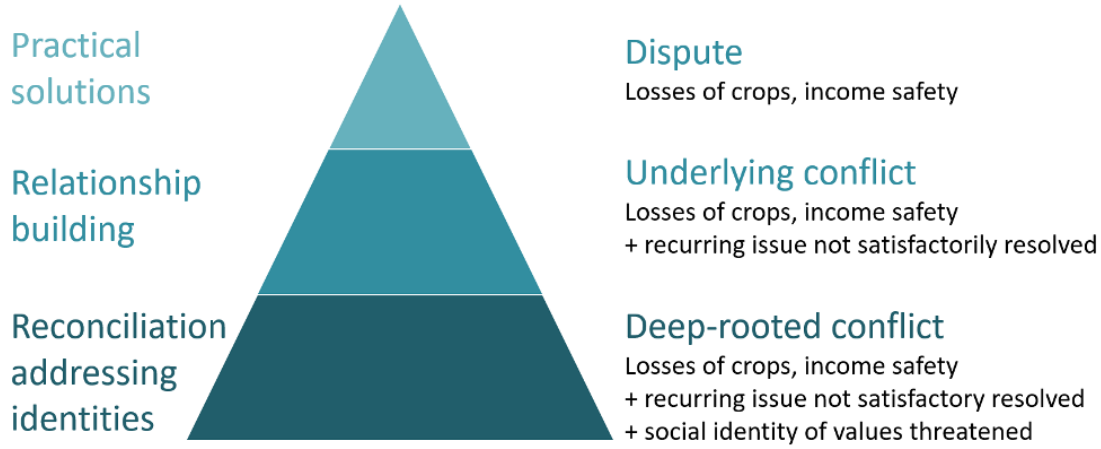

Figure 3 Three levels of conflicts and how they should be addressed, based on Zimmermann et al (*subm.)*.

Practical solutions, like technical or financial HEC mitigation measures will only be successful in addressing the dispute level of the conflict (Zimmermann et al. subm.), characterised e.g. by damaged crops or lost income (Figure 1). If, however, an issue comes up over and over again and cannot be satisfactorily resolved on the practical level (e.g. the feeling of HEC victims that governmental authorities do not react adequately to their losses), the relationships between the different interest groups may have to be reflected and reshaped (Pooley et al. 2016). The basis of trust between the stakeholders is highly important for clarifying underlying conflicts (NPCC and WWF-Bhutan 2016). At this level good governance, transparency and intensive communication between all players of HEC management and elephant conservation is highly important. Only by shaping trustful relationships can underlying conflicts be solved. Deep-rooted conflicts are seldom visible at first glance and need detailed background information for identification. Often injustice of the past is a cause for deep-rooted conflicts. The resettlement of people from protected areas, access restriction to culturally important places or illegalisation of hunting for local people are examples of such deep-rooted conflicts. Such issues can only be tackled through an intensive reconciliation process taking seriously into consideration the identities of the players. It is important to understand that long-term conflict resolution can only be possible if deep-rooted underlying

conflicts are identified and adequately addressed. This has long been the major shortcoming of HEC management (Madden and McQuinn 2014).

Finding solutions to HEC finally requires tackling the human-human-conflict over elephants. If all levels of conflict can be addressed, tolerance can be shaped. However, it must be understood that the shaping of tolerance needs to take place on both sides: on the farmers' side for the residual risk of living with elephants and on the conservation side for limits to elephants' population size and movement.

1.6 Material and Methods of this study

The objective of this study is to create a comprehensive overview of the current state of HEC on the African continent with a focus on which measures work where, why and how. The broad and complex subject of HEC has been studied by research and conservation institutions since the 1990s. At first, studies were particularly focussing on technical measures and monitoring. Since the past ten years the discussion about HEC and HWC in general is broadened. Social aspects and the human dimension became more relevant for research, focussing e.g. on understanding how tolerance is shaped and which role risk perception plays.

The basis of this study is a literature review, taking into consideration more than 100 scientific papers and grey literature reports. As research articles and reports may not always reflect the views of practitioners on the ground, 23 qualitative interviews were conducted. The interviews were guideline-based (see Appendix) with open ended questions, targeting on narrative in-depth answers, as used in qualitative social research. Interviews took 50 to 180 minutes and were recorded. The recorded interviews were roughly transcribed and analysed by synthesizing information regarding all six areas of operation on HEC (Figure 1), as well as on perception of elephants and relationships between different stakeholders. The interview partners were Anglophone and Francophone experts, who had spent considerable time working in conservation areas on the topic of HEC. All of the interviewees work or have worked for local or international non-governmental or governmental conservation agencies/organisations.

HEC is a complex topic involving social, cultural, and political dimensions and at the same time dealing with a highly intelligent social animal, whose behaviour and ecological needs are still not fully understood. On top of that, this species is still present in 37 African countries, all with different cultural backgrounds and political situations. A study like this, therefore, had to draw lines and concentrate on the most relevant and most recent topics regarding HEC. Despite its length it is still only an excerpt of the challenges and potential solutions people and elephants are facing on the African continent.

HEC Monitoring

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2 HEC monitoring

2.1 How HEC data are collected today

Up to this day, the determinants for HEC have not been fully understood. To be able to tackle this conservation issue effectively, ecological and social factors have to be taken into consideration and comparable HEC data need to be produced. The need to collect objective HEC data was emphasized by several interviewees of this study and is supported by scientific literature (Stem et al. 2005, Stuart-Hill et al. 2005, Songhurst 2017). Data on the frequency and extent of crop and property damage and numbers and background of fatalities on the peoples' and elephants' side through negative interactions are the basis for informed and evidence-based decision making. The need for an objective data collection is seen, because subjective data cannot be related to the real extent. Furthermore, the location of the damage is seen as very important for mapping areas of high damage and changes over time.

"A standardized monitoring of HEC is key to informed decision making"

Statement by interviewee 00J

In the 1990s a first step was made to produce more comparable data with the AfESG of the IUCN. This group discussed and set-up plans to foster the research on HEC and has published and recommended a standardized approach for the assessment of damages caused by elephants (Hoare 1998). However, this effort was focussing on the damage caused to an individual farmer only, and did not take into consideration the use of mitigation strategies or differentiate between damage caused by trampling and feeding.

Multiple studies have been conducted since then, using modified research designs and methods (Sitati et al. 2003, Sam et al. 2005, Okello et al. 2014, Pozo et al. 2017b). Many research and conservation organisations have developed their own monitoring schemes and tools to evaluate HWCs, however, most of them have been developed without using comparable formats.

Data collection by wildlife authorities

Wildlife authorities generally collect HEC data within a financial compensation framework or for monitoring purposes on paper and on victims' level. Departments, however, are often facing difficulties in carrying out this assessment properly, due to manpower, technical or transportation constraints (Table 1). Interview partners mentioned that particularly data collected on crop damage by wildlife authorities was often patchy and lacking geo-reference. Human fatalities caused by accidents with wildlife are generally followed up by wildlife departments, although reactions can take a few days' time (interviewee 00B and 00I).

It is generally perceived that data collected by wildlife departments mainly are filed, but not really used by the agencies and not reported back to the communities. In some cases external NGOs or university students make use of the HEC data collected by wildlife departments for analysis and planning (interviewee 00T).

Table 1: Advantages and challenges of HEC monitoring schemes conducted by wildlife authorities.

PROs	+ Demonstration of good will + Simple paper system + Low cost	CONs	- Data collected patchy due to constraints of labour, tools and transportation - Biased data due to auto-correlation if collected on victims' level - Slow response and slow (if any) data analysis - No maps produced - No feedback to communities

Data collection by the community: Example Namibia

Namibia's Community Based Natural Resource Management (CBNRM) program is a joint venture between government, national non-governmental organisations and rural communities. One component of the program involves communities in monitoring various aspects of their conservancy including damage caused by wildlife (Table 2). This is conducted by the use of an Event Book System, for which the community dictates what needs to be monitored (Stuart-Hill et al. 2005). Scientists facilitate the design process and conservancy members undertake all data analysis. Local game guards, who are hired by the conservancy with the aim to monitor wildlife and stop poaching, conduct the assessment. In case of damage caused by wildlife the game guards are called and take down information on date, location, species causing damage and damage on farmer/victim level. This data will later on be used for claiming offsets under a self-reliance scheme (see chapter 3.3.1). Every month game guards meet and report on what was observed. Simple descriptive statistics are prepared by adding up e.g. crop damage per elephant per month by the conservancy manager. Thus, crop, property, and livestock damage and human fatalities are taken down per species, and a comparison between months and between years becomes possible. Furthermore, simple maps are developed by marking the area in which a damage occurred. The event books (which also contain information about signs of endangered species, death of wildlife species and poaching incidents) are audited by external scientists and supporting communities in setting hunting quotas or advising on HWC mitigation strategies.

Table 2: Advantages and challenges of HEC data collection by a community conservancy.

PROs	+ Quick compilation of data + Data collected by game guards, who also do wildlife monitoring + Strong involvement of community and ownership of data by conservancy + high coverage due to community participation and offsets through self-reliance scheme + Production of simple maps, charts and tables (paper) + Compatibility with anti-poaching data + Baseline data for land-use planning	CONs	- Biased data due to auto-correlation if collected on victims' level - Very brief data, no details on how crop got damaged, whether they were protected, stage of growth etc. - In remote areas data on HEC takes long to be reported to MET (e.g. in case of emergency issues)

SMART data collection by NGO: Example South Luangwa, Zambia

Conservation South Luangwa (CSL) collects HEC data by means of hand-helds operating on the SMART (Spatial Monitoring and Reporting Tool) application (Table 3). Trained HWC officers closely observe all damage caused by wildlife in a defined area. The underlying HWC assessment scheme involves multiple species, taking into consideration spatial, ecological, social and economic factors (Gross 2018). Damage caused by wildlife species are assessed by locally trained HWC officers supported by HWC informants. The assessment comprises of field observations (tracks, marks, damage size, and landscape characteristics), marking of the geo-reference, as well as structured interviews with victims and witnesses. For this assessment four types of HWCs are categorized: crop damage (crops on farmland damaged by herbivores), property damage (houses, food storages, livestock shelters, fences or vehicles damaged), livestock predation (livestock injured, killed and/or displaced by predators), and human accidents with wildlife species, either by herbivores or carnivores, leading to human injuries or death. The assessments are based on damage events; these are defined as damage by one wildlife species (group or individuals) caused during one time period (e.g. one night) in a defined area. In case a group of elephants damage fields of several farmers, data will be collected on the event level. Socio-economic details of damage will be collected on farmers/victims level and are attached to the event. The collected data is downloaded to a HWC data computer, on a weekly basis. Pre-defined queries allow a quick summary of data, production of charts and tables as well as maps. An HWC report is produced on a monthly basis by CSL and shared with the Department of National Parks and Wildlife (DNPW).

Table 3: Advantages and challenges of HEC data collection via SMART application.

PROs	+ Quick compilation of data + Production of maps, charts and tables + Autocorrelation of data is reduced + Identification of HEC hotspots possible on different levels + Compatibility with anti-poaching data + Baseline data for land-use planning	CONs	- Labour intensive - Cost intensive (tools, transportation) - Access to some farming areas may be limited during rainy season - Dark numbers (unreported damage) unknown - Raising expectations of community members

2.2 Constraints and challenges for HEC monitoring

Although the importance of HEC monitoring data is obvious, most countries and programmes on the African continent seem to be facing constraints. The lack of comparable data on HEC decreases the possibility of analysing factors and drivers of HEC between different regions and species, thus making a global understanding impossible (Sitati et al. 2003). The need for a uniform system of data collection and a standardized database has been identified for the support of management decisions to reduce damage by wildlife species (Nyhus and Tilson 2004, Goodrich 2010, Poessel et al. 2013, Poledníková et al. 2013) and was mentioned by several interview participants. The lack of a uniform data collection also makes it difficult to define sound and smart indicators for HEC mitigation programmes. In Kenya the lack of reliable data on crop damage caused by elephants

lead to the development of an unrealistic compensation scheme in 2014, which now proofs to be failing (interviewee 00J).

Furthermore, the HEC data collection scheme developed by the AfESG in the late 1990s was designed when satellite imagery, digital data collection and GPS tracking of elephants were not readily available. A revision therefore might be advisable.

Box 3 Background: The issue of autocorrelation in HEC data

Another important issue regarding most of the HEC monitoring schemes used is auto correlation. As advised by the AfESG, HEC data are mostly collected on farmers/victims level. Frequently elephants do not only damage one field and move back to their natural habitat, but damage crops on fields of different farms located in the same area (e.g. a farming block). As an example, the same elephant damages the fields of five different farmers. The data collected on farmers' level does not show the connection between these five incidents. When analysing the data it is not taken into consideration that the five sets of data are connected. They are analysed as if they were independent. Why is that important? In areas with smaller fields located close together, elephants will very likely damage more fields of different farmers than in an area with large scattered fields. The analysis, however, will reveal a higher frequency of damage in the farming block. The same applies to ecological factors and group sizes of elephants (which are not influenced by the field size), which will be biased in the analysis. Analysing the frequency of crop damage over time might also get biased, as over time and with growing human population field size may reduce and become more compact. Even if the number of crop damage events will stay the same and elephants will damage the same extent of crops, data analysis based on farmers' level would reveal an increase in damage frequency.

Programmes focussing on community-based HEC mitigation approaches use specifically trained community members for the collection of HWC/HEC data (Songhurst 2017, Gross et al. 2018). This is important as rangers conducting anti-poaching and wildlife monitoring patrols are seldom trusted as helpful to the communities. Particularly in areas with underlying or deep-rooted conflicts the involvement of governmental agency officers in emotionally difficult situations caused by big losses to wildlife may cause a further intensification of conflict. An exception is seen in CBNRM areas, where the wildlife causing damage is directly linked to income generating activities of the communities or even under the custody of communities (O'Connell-Rodwell et al. 2000).

Another constraint is the large black number of unreported HEC cases, where well-developed HEC informant systems and a good relationship with the farming community is lacking. In Hwange District in Zimbabwe, e.g. a significant proportion farmers (40%) does not report damage to anyone, as they just do not know whom to report to or would have to travel far (Le Bel et al. 2016b).

2.3 Perspectives: Developing a globally applicable HWC monitoring scheme

The lack of comparable data on HEC decreases the possibility of analysing factors and drivers of HEC between different regions and species, thus making a global understanding impossible (Sitati et al. 2003). Compared to anti-poaching data collection systems, involving SMART and real-time systems like Earth Ranger, HWC monitoring systems are generally lacking behind. For a well-informed, evidence-based decision-making process on HEC mitigation strategies the combination of elephant movement and occurrence data as well as poaching data seems to be the way forward.

However, as explained above, HEC data are collected on communal and private land and should be collected by individuals trained in mediation of conflicts and HEC prevention/mitigation techniques. A mixing of interest by using HEC informants and mediators, e.g. for the collection of information on illegal activities, has to be strictly avoided, to not misuse the basis of trust created with the community. Furthermore, a report of data back to community is compulsory.

A comprehensive HEC monitoring scheme should serve for a spatial and temporal analysis of HEC trends, capturing the frequency and magnitude of different types of damage. It further should take into consideration the severity of a damage relative to the income/dependency situation as this influences the resilience of victims to HEC. As HWC includes both sides, wildlife and people, it should further integrate the attitude of the victims (ideally the level of tolerance towards damage by elephants). An overview of protection measures used and measures the victims would like to take should be included, whereas the effect of newly implemented HEC mitigation or prevention measures should be evaluated separately in a standardized and scientifically sound approach.

Furthermore, HWC/HEC data collection has to reduce the likeliness of auto correlation. As proposed by Naughton-Treves (1998) and Gross (2018), damage events should be defined as damage by an individual or group of one wildlife species during one time period (e.g. one night) in a defined area. Elephants, e.g. damaging the fields of four different farmers in one night need to be recorded as one damage event with four occurrences of crop damage. In this way, spatial autocorrelation is reduced, which could result from clustered damage events caused by one species individual or group (Songhurst and Coulson 2014). HEC data collected in a scientifically sound way could ideally be modelled together with elephant movement data as well as data on needs regarding local livelihoods and household production. Such models would be very helpful to support decision-making regarding the spatial and temporal use of a landscape on large and fine spatial scales, befitting both, people and elephants.

It must be taken into consideration that HEC data collection is expensive. Large areas require a substantial number of well-trained HEC officers with good equipment and transportation. In the future, frequency of damage may even rise, so a well-designed sampling might be advisable. Furthermore, an elaborate HEC data collection system necessarily creates expectations in the farming community. Communication needs to be transparent and clear to avoid misunderstandings. Finally, resources will have to be balanced between data collection and support for mitigation measures. The implementation of citizen science models for HEC data collection might also be a way forward to decrease costs, involve communities and gain large data sets (participant 00N). This novel idea could be worthwhile exploring further.

HEC prevention and mitigation

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3 Strategies for HEC prevention and mitigation on the African continent

3.1 Political framework for HEC management

In colonial times the State generally took control over all natural resources across Africa. This was particularly true for the large and economically valuable wildlife species. The State itself, therefore, established rules for the protection and hunting of game species (Parker et al. 2007). Local people mostly were excluded from the right to hunt large mammals, such as elephants. Today, States retain responsibility for elephants, as their legal custodians. The main involvement of governmental bodies (e.g. through wildlife agency or national park department) in terms of HEC management includes problem animal control (PEC) (see also chapter 3.4.8) and disturbance shooting. In a few cases governmental compensation schemes are applied (see also chapter 3.3.1). However, with the development of community-based conservation (CBC) approaches, in some areas the responsibility for elephant management is being devolved to local level.

Today, governments of the elephant range States are well aware of the importance of HEC and the need to develop and implement strategies to tackle these problems. The reduction of HEC is the third of eight objectives of the African Elephant Action Plan (AEAP), which was adopted in March 2010 at the 15th meeting of the Conference of the Parties to CITES in Doha, Qatar. The Plan was developed over two years through a consultative process, facilitated by the AfESG of the IUCN and the CITES Secretariat. The AEAP is fully owned and managed by the African elephant range States, and outlines the actions that must be taken in order to effectively conserve elephants in Africa across their range (IUCN 2019a). The African Elephant Fund (AEF) assists with the implementation of the strategy.

The Strategy for the Conservation of West African Elephants was firstly published in 2003, revised and updated in 2005. The strategy forms the basis for a Memorandum of Understanding (MoU) between all 13 Range States in West Africa, under the umbrella of the Convention on Migratory Species (CMS). The CMS West African Elephant MOU provides an international framework for Range States, NGOs, scientists, local people and the international community at large to collaborate in the restoration and maintenance of elephant populations and their habitats in West Africa (CMS 2005). With a strong focus on tackling the loss of elephant habitat and the illegal killing of elephants, HEC mitigation is less strongly emphasized in this MoU, but mentioned under “Reduction in the Rate of Loss of Elephant Range”. Nevertheless, the need for fair and effective compensation for crop damage by each State is explicitly addressed as well as the reduction of HEC, by engaging communities in activities that do not require them to encroach upon PAs. The development of new techniques of deterring elephants from visiting farmland and the training of rapid-response teams to deal with cases of problem elephants are listed as planned activities (IUCN 2005). Since 2017 the CMS parties endorsed the AEAP as the principal strategy adopted by the African Elephant Range States.

Some African alliances relevant for conservation and development also developed international strategy papers for the alignment into national strategies. Whereas the Central African Forest Commission (COMIFAC) developed a strategy on HEC mitigation for 2010-2014, the Southern

African Development Community (SADC), has not integrated HEC mitigation in its Law enforcement and anti-poaching strategy. The strategy mentions the aim for direct community involvement in wildlife management, but does not elaborate on HEC. Nevertheless, the Southern Africa Regional Elephant Conservation and Management Strategy prepared by SADC in 2005 has a strong focus on HEC mitigation (SADC 2005).

The diversity of international and multilateral elephant conservation agreements including HEC mitigation and action plans demonstrates a strong awareness and relevance of the topic. In dependence on the multilateral elephant conservation agreements, national elephant conservation strategies were developed. The national strategies on elephant conservation and/or HEC mitigation are listed on the IUCN AfESG website (IUCN 2019b). Table 2 gives an overview of 17 most important strategies and comments on the mention of HEC. This list shall give an overview of the multiple political instruments developed in the past, as these are important for embedding future HEC mitigation strategies. It has to be understood that this list is only a rough summary and does not replace a detailed analysis and evaluation of the national elephant conservation strategies.

Table 4 Summary of 17 national strategies and management plans on African elephant conservation and their mention of HEC topics, based on IUCN AfESG website information.

Country	Title	Year	Comments on HEC
Benin	Stratégie de la Conservation de l'Elephant au Benin	2005	Support system for victims mentioned
Burkina Faso	Stratégie et Programme de Gestion Durable des Eléphants	2003	Mentions the need to reduce crop damages but explains there is no proper solution.
Botswana	National Policy and Strategy for the Conservation and Management of Elephant in Botswana	2003	HEC mentioned as one of the four major issues for elephant management and its reduction is one of four primary objectives: HEC monitoring and community participation and financial measures. PEC as last resort.
Cameroun	Stratégie et Programme de Gestion Durable des Eléphants au Cameroun 2011 - 2020	2010	Reduction of HEC mentioned as one of eight objectives. Needs in capacity of HEC management is mentioned, HEC monitoring and response teams.
Ivory Coast	Stratégie de Gestion Durable des Eléphants en Côte d'Ivoire	2005	Elaborates strongly on HEC: monitoring, cooperation with community, alternative income generation, rapid response teams, propagation traditional methods.
Gabon	Stratégie Nationale et Plan d'Actions de Gestion des Conflits Homme-Faune au Gabon	2010	HEC plays a major role, social, financial, technical and spatial measures to HEC mitigation are advised.
Ghana	Strategy for the Conservation of Elephants	2000	Reduction of HEC mentioned as one of eight objectives. HEC monitoring, Training of farmers in crop protection HEC management, evaluation of feasibility of fencing, PEC as a last resort.
Guinea	Stratégie Nationale de Gestion des Eléphants en République de Guinée	2008	Reduction of HEC mentioned as one of eight objectives. HEC evaluation, formation of HEC management committees and prevention as well as financial strategies are mentioned.

Guinea Bissau	Stratégie de la Conservation de l'Eléphant au Guinée Bissau	2000	It is explained that due to low elephant numbers an isolated habitat HEC does not play a role.
Kenya	Conservation and Management Strategy for the Elephant in Kenya 2012-2021	2011	Peaceful coexistence of elephants and people mentioned in long term vision. HEC reduction as one of seven strategic objectives. Monitoring, social, financial, spatial and technical strategies mentioned.
Mozambique	Strategy and Action Plan for the Conservation and Management of Elephants in Mozambique 2010-2015	2010	Reduction of HEC mentioned as one of three main targets and focusses on HEC mitigation through community participation, spatial planning and increased benefits.
Namibia	Revised National Policy on Human-Wildlife Conflict Management, 2018-2027	2018	HEC plays major role: policy binding for conservancies. Definition of HEC zones, development of HEC management plans for conservancies, land-use planning and environmental impact assessment, focus on social and financial strategies.
Niger	Stratégie Nationale et Plan d'Actions pour la Conservation Durable des Eléphants au Niger	2010	Reduction of HEC mentioned as one of four objectives. Participatory approaches for HEC prevention and management are mentioned as well as a support system for HEC victims.
Tanzania	Tanzania Elephant Management Plan 2010-2015	2010	Reduction of HEC mentioned as the first of nine objectives. Needs for coordinated action in HEC mitigation emphasized, PEC seen critical, promotes participatory land-use planning.
Togo	Stratégie pour Conservation des Populations d'Eléphants au Togo	2003	Reduction of HEC mentioned as one of five objectives. Besides HEC monitoring, early warning systems and livelihood development activities, the recognition of customary land rights is brought up.
Zambia	National Policy and Action Plan on Elephant Management in Zambia	2003	HEC mentioned as major threat to elephant population and HEC reduction mentioned as first of nine objectives: HEC monitoring, PEC, decentralized decision-making, revenue sharing.
Zimbabwe	National Elephant Management Plan, 2015-2020	2015	HEC not mentioned in key objectives. Implementation of HEC techniques, land-use strategy and monitoring mentioned as key actions in the social, economic and cultural frameworks.

The development of clear political frameworks on national and multilateral levels as well as their implementation in communities living with elephants is crucial for the success of long-term strategies. Nearly all national strategic documents on elephant conservation give a high priority to HEC mitigation, some countries have even developed their national HWC/HEC mitigation strategies. Such detailed national HWC/HEC action plans are helpful to guide wildlife agencies or national park departments as well as communal bodies and NGOs in designing programmes and defining responsibilities. National action plans on HEC also support the allocation of budgets to carry out HEC mitigation work.

3.2 Social strategies for HEC mitigation

Conflicts can only be resolved by the inclusion of all parties playing a role in that very conflict. The participation of local farming communities, local authorities, governmental institutions and conservation agencies is indispensable. When working towards long-term solutions to HEC, it has to be understood that HEC is a conflict of people over wildlife and over the use of natural resources. In areas where communities do not have the ownership or custodianship over the wildlife they are living with, the true conflict generally takes place between the farming community and the representatives of the wildlife authorities. In such situations farmers see elephants as "the governments cattle" (O'Connell-Rodwell et al. 2000) and feel neglected when wildlife authorities react immediately to poaching incidents but not when a person gets killed by an elephant (interviewee 00H). Only by taking the attitudes, needs and fears of community members seriously and dealing with community stakeholders as transparent and fair as with others, trust will be built up, which is the basis for conflict resolution.

3.2.1 Participatory and inclusive strategies

Managing HEC means aiming at the interaction between wildlife and people to achieve goals valued by stakeholders. This requires considering views, attitudes and needs of stakeholders whose co-operation and support is necessary to achieve conservation goals (Kansky et al. 2016). HEC management ideally would be a process of mediating a balance of tolerance between the different stakeholders and wildlife persistence (Table 5). On the one hand it is important to understand the position of community members, who did not receive any support by the government (Mariki et al. 2015), on the other hand the limitations of wildlife agencies need to be understood as well. When implementing and conducting a participatory process, wildlife agencies need to be aware that they will be closely and critically observed by community members. Taking this challenge means opening up for an overall improvement in governance.

In general wildlife authorities have the legal mandate to manage HEC and are operating under the Ministries of Environment or Resources (see also Chapter 5.1). The wildlife authorities then appoint managers for these problems. In case of non-transparent governance (even within CBNRM programmes) a negative attitude towards the wildlife authority and its representatives is created among the community members (Le Bel et al. 2011). The development of mistrust, negative attitudes and anger is the consequence.

Picture 2 Involving local stakeholders into an open dialogue on HEC mitigation strategies in North Luangwa, Zambia. © E. Gross

To avoid the loss of trust between the various stakeholders involved in the HEC, transparent governance is the basis. Involving community groups and members and other stakeholders into an open dialogue and with shared information is highly important. In general meaningful

local participation with clearly defined roles and strong community ownership of the process will lead to higher acceptance and tolerance of the conservation work (De Boer and Baquete 2002, Treves et al. 2009, Mariki 2013). Therefore, building up a partnership, a trustworthy work relationship based on mutual respect and understanding between parties directly involved in HEC issues is essential (Arnstein 1969, Cornwall 2008). Interviewee 00T emphasizes the positive results from collaborative wildlife management approaches: "*In the past the Wildlife Department has been working in military style, without consulting with communities. There was only protection of resources, no sharing of knowledge, no feedback into communities. So over time communities were even feeling suspicious over what was happening in their lands, because originally this land belongs to them. Today collaborative wildlife management, bringing local communities into the management of our wildlife resources, this has improved relationship*".

Table 5 Advantages and challenges of participatory and inclusive strategies for HEC mitigation.

PROs	CONs
+ long-term strategy + involves all stakeholders + flexibility + potential to generate new solutions to problems + builds trust and a basis for shaping tolerance + power and responsibilities are shared	- needs long-term presence and funding - team of good community workers needed - constant process

3.2.2 Community outreach: Working on relationships, awareness, and tolerance

The first step towards a higher level of participation of local communities is information and consultation of local stakeholders, starting a dialogue about the perceptions of HEC and understanding the underlying causes of conflict. Building up relationships should be in the focus at this point. To introduce "solutions" too early might just fail, due to low level of acceptance and participation.

It's the human touch that counts!

Statement interviewee 00B

Understanding the relationships between stakeholders is vital to build up a long-lasting strategy for HEC prevention and mitigation (Table 6). The relationships can vary strongly from area to area, based on the history, culture, governance and balance of power in the respective areas. Interviewees have described the relationship between the local communities and the conservation agencies/organisations as varying from very difficult to cordial. Interviewee 00E for example states that "*There is a lack of response to crop and property damage by the wildlife authority, so the relationship is difficult between community and authority. Something has to be done*." Interviewee 00B explains that "*the team can go out to do HEC assessment, not being perfectly welcomed, but accepted*". In another area, interviewee 00V speaks about a "*peaceful and cordial working atmosphere*". Particularly in areas where a crack-down of order took place due to political unrest or a massive poaching crisis, strong trust-building is needed (interviewee 00O).

When conservation organisations start working with local communities, they are often confronted with mistrust (interviewee 00H). O'Connell-Rodwell et al. (2000) discribes the construction of an electric fence around an agricultural area, to keep elephants out of fields, in Caprivi/Namibia was firstly misinterpreted by the community as a measure to increase the size of the NP. Many organsiations report that it takes up to 3-5 years of continous work with the community until a basis of trust is developed, which is needed to build up proper long-term HEC prevention and mitigation startegies. Interviewee 00B explains: *"[After working about 10 years on HEC mitigation with communities] the relationship between farmers and wildlife authority is not strongly emotional anymore. Still people are upset and ask for compensation, but the emotional level has gone down. Now, we are able to work together*". Interviewee 00V emphasises that "*After 10 years of intensive community work results are visible. There is much more tolerance towards HEC in the farming community!*"

The following aspects have been mentioned as being crucial for building up trust and a good working relationship between the HEC stakeholders:

- Availability of contact person
- Closeness to community
- Show understanding for the situation
- Demonstrate that things are being done
- Open dialogue, communication
- Sharing of knowledge
- Feedback into communities

Picture 3 Informing farming community about HEC: Personal interlocution in South Luangwa, Zambia and community information meeting in the Okavango Panhandle of Botswana. © E. Gross, Awely and Ecoexist

In terms of HEC management NGOs generally see themselves as a bridge between community and governmental authority. On the one hand, NGOs are supporting the wildlife authorities in being more efficiently and effectively fulfilling their role in law enforcement, on the other hand they are working with communities to find ways of coexistence with wildlife. Interviewee 00N explains "*The NGO is taking the role to […] bring community and wildlife authority closer together. Because we [NGO] are working more on these things that are directly benefitting the communities. We are also working together with the department, so communities slowly understand that wildlife*

authority plays an important role. If we work together continuously, the relationship will be build up even better".

Limitations of such concepts are seen in short term funding of NGOs, particularly international organisations. Interviewee 00N states "*Sustainable solutions will not be found as long as NGOs are involved. They are only as sustainable as the last grant*". For this reason, the necessity to rather support local NGOs with capacity building on HEC management and participatory approaches was highlighted (interviewee 00T). Local NGOs generally have long-term commitments, are rooted in the project area and are operating with small overheads.

Taking the role of connecting community and wildlife authorities is mostly seen as strength of NGOs. However, such concepts have their limits, particularly when transparency is lacking. The mixing of anti-poaching work and community work needs to be avoided (interviewee 00N), as community workers might lose the basis of trust in the community if they are regarded as undercover informants. Furthermore, the set-up of law enforcement and community work needs to be well thought through, planned and communicated to the stakeholders. If scouts or rangers are involved in community work, e.g. through the support of rapid response teams to HEC, specific training is needed. The abuse of power has to be strictly prohibited, and human rights have to be protected at all times.

There are multiple ways of community outreach work, ranging from informal talks with farmers facing crop damage by elephants to delivering exchange programmes to members of community conservancies (Figure 4). Whatever measure is taken, it needs to be targeted at specifically defined groups of people and therefore the community structure needs to be understood. It is a frequent misunderstanding that groups of farmers are a community with a spokesperson and would act as whole units. However, very often they are mixed groups with different stakeholders (e.g. village heads, family groups, newcomers, and widows).

Trainings or information campaigns should target on topics like:

- How to behave when chasing away elephants (interviewee 00B and 00I).
- How live safely with elephants (particularly in areas where people did not grow up with elephants or have lost knowledge about them) (interviewee 00C).
- What to do when damage occurs: communities need to know wildlife policies and legislation and how to e.g. fill compensation claims (interviewee 00I).
- How HEC is addressed in other areas (interviewee 00A).
- Understanding of benefits through wildlife (interviewee 00J).

Table 6 Advantages and challenges of community outreach programmes on HEC.

PROs	+ reaching out to large number of people + long-term strategy + foundation is built for many different measures to be taken + democratic process	CONs	- long-term presence needed - skilled (wo)manpower needed (community workers) - high cost - may take some time to show first results

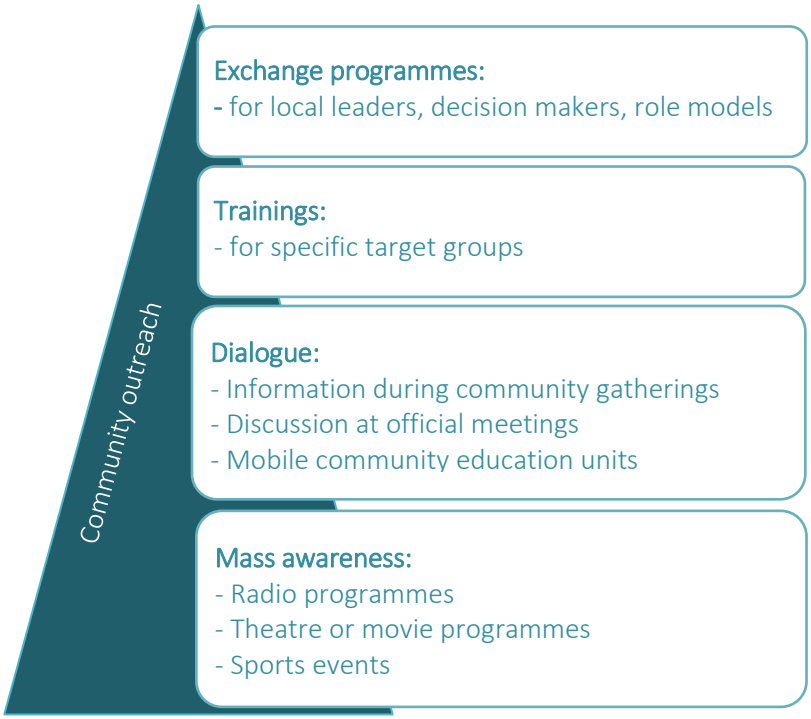

Figure 4 Community outreach programmes conducted by interview partners.

3.2.3 Education programmes in schools

Picture 4 Learning about elephant behaviour in school, South Luangwa, Zambia. © E. Gross, Awely

Specifically designed educational activities and raising of awareness for the importance of elephant conservation are seen as crucial for the long-term coexistence between elephants and people (Madden 2004) (Table 7). However, only a few programmes seem to work on this topic in a strategic way. If HEC programmes are to achieve long-term success for the safe coexistence of people and elephants, educational programmes need to be reviewed and objectively evaluated.

As the perceptions and attitudes of people who inhabit conflict prone areas are crucial to the management of HWC (Ogra 2008, Hill and Webber 2010, MacKenzie et al. 2017) and the design of educational activities, site specific information regarding the perceptions and attitudes towards elephants need to be understood.

Educative programmes bear the potential to shape values, build tolerance and prevent or mitigate fear. In many African areas educational programmes can be built on the traditional and spiritual knowledge of the people. Giving back own traditions and building on old knowledge that has been

lost, may be the basis of developing local pride for elephants. Such approaches are as important as passing on scientific knowledge on the role of elephants for the ecosystem or teaching about the fascination of elephants' complex social behaviour. After having conducted intensive educational school programmes on conservation and HEC mitigation, interviewee 00B states: "*Children are thrilled when they hear there is an elephant close by and they take a peek at from a safe distance. I think there is a true appreciation and understanding of the significance that elephants have in the ecosystem and for the tourism economy*".

However, it has to be understood that changing attitudes does not directly lead to a changed behaviour (Waylen et al. 2009). For this, easily adaptable and beneficial courses of action need to be offered as well.

BOX 4 The value of elephants

In different parts on the African continent elephants are valued in various ways. As pastoralists, Maasai value elephants for fertilizing the land and many traditional beliefs shaped a positive perception of the pachyderms (interviewee 00J). Also for the Himba and Herrero of Namibia elephants hold a high cultural value and play an important role for the identity of the people (interviewee 00C and 00F). Interviewee 00C explains: "[*the Himba*] *held elephants in very respectful position,* […] *in many spiritual rituals elephants are used in a positive way*". In Western African countries, elephants are deeply rooted in the culture of people as they are appreciated for their strength and braveness (interviewee 00T and 00V). In the arable farming areas of Southern Africa, more neutral perceptions are described. Interviewee 00M states: "*People work on their fields or shelters while elephants are roaming around them peacefully*". If crop damage would not happen, problems with elephants would not arise (interviewee 00E, 00M, 00Q, and 00R). Fear, however, shapes negative perceptions, as interviewee 00C emphasizes: "*People are frightened and they think they are going to be killed when they see an elephant. The fear element is very important to face".* Particularly in southern Tanzania and Mozambique it was mentioned that people had a very negative attitude towards elephants: "*Most people we speak to really hate elephants. They cause big damage, they don't bring value, they are scary and they do kill people. I think there has never been a time where elephants have not played a negative role […]*" (interviewee 00O). The negative perception of elephants in the region is further explained by the history of colonial times, where ivory business and slave trade were combined and the wealth gained through ivory fostered the repression of the local people (interviewee 00D and 00I). For this reason "*elephants are mostly perceived as an indication of underdevelopment*" (interviewee 00M).

There are several options of conducting formal or informal education programmes targeting pupils. Depending on the persisting values, the type of school and syllabus, the level of education and age groups of pupils, programmes have to be designed according to defined goals. Particularly in schools close to NPs or in other HEC prone areas, the integration of HEC topics, such as responsible behaviour towards elephants, skills on how to prevent accidents and property damage, into the

school syllabus, is an ideal option to reach out to a large number of pupils. Specific teacher trainings and the development of educational resource packs for teachers assist the easy integration of HEC topics into the curriculum (interviewee 00D). Where HEC cannot be integrated into the school syllabus, educational visits to schools may be an option. Afternoon wildlife clubs are targeting a smaller number of pupils but can offer a more intensive programme for selected individuals (interviewee 00B and 00G). Offering scholarships for particularly interested and skilled local students is seen as an important initiative, particularly in rural areas where people generally are underprivileged in terms of education (interviewee 00G).

Besides bringing HEC topics to the school, taking pupils into the PAs is another approach. The creation of non-stressful wildlife encounters can influence attitude and enable the creation of affection (interviewee 00L) (Ballantyne et al. 2007).

No matter which type of educational programme is selected, a pre- and post-evaluation is indispensable to understand whether and how the goals of enhanced knowledge and attitudes are reached. However, evaluation is often lacking (Scrizzi et al. 2018) and needs to be practiced more rigorously to improve results.

Table 7 Advantages and challenges of education programmes in schools.

PROs	+ creates basis for future activities + large target groups + strong impact on knowledge and tolerance + builds identity + long-term effects	CONs	- long-term investment - effects show slowly - no direct effect on behaviour

3.2.4 Perspectives: Preparing the ground for coexistence

HEC management has to be sustainable in the long-term and is therefore ideally administered by the local community itself. However, the African elephant with its high protection status falls under the protection of the government. Communities and governmental authorities therefore need to work transparently together. Political measures, good governance, creation of trust, and reliability can only be achieved through inclusion and participation. For this reason, community members directly involved in HEC need to be included into the process.

In the past, a lot of emphasis has been put on the development of technical strategies to reduce HEC. A reduction of damage, however, does not directly lead to more tolerance against elephants and to the support of conservation activities. Social measures are important to work on the perceptions and attitude to shape tolerance and the will for coexistence. These aspects currently seem to be underrepresented in many programmes.

> *"We need to change the narrative on HEC and put the people in the centre, not the elephants. We should talk about coexistence instead of conflicts."*
>
> Statement interviewee 00P

Teams working on HEC prevention and mitigation ultimately have to build their capacities in transparent, democratic, and participatory methods of planning and implementing projects. HEC

represents a fundamental challenge for conservation: reconciling local concerns for security and economic growth with international concerns for saving a threatened species (Treves et al. 2006). As suggested by Treves et al. (2007) a procedure for a successful co-management of HWC should include four major steps:

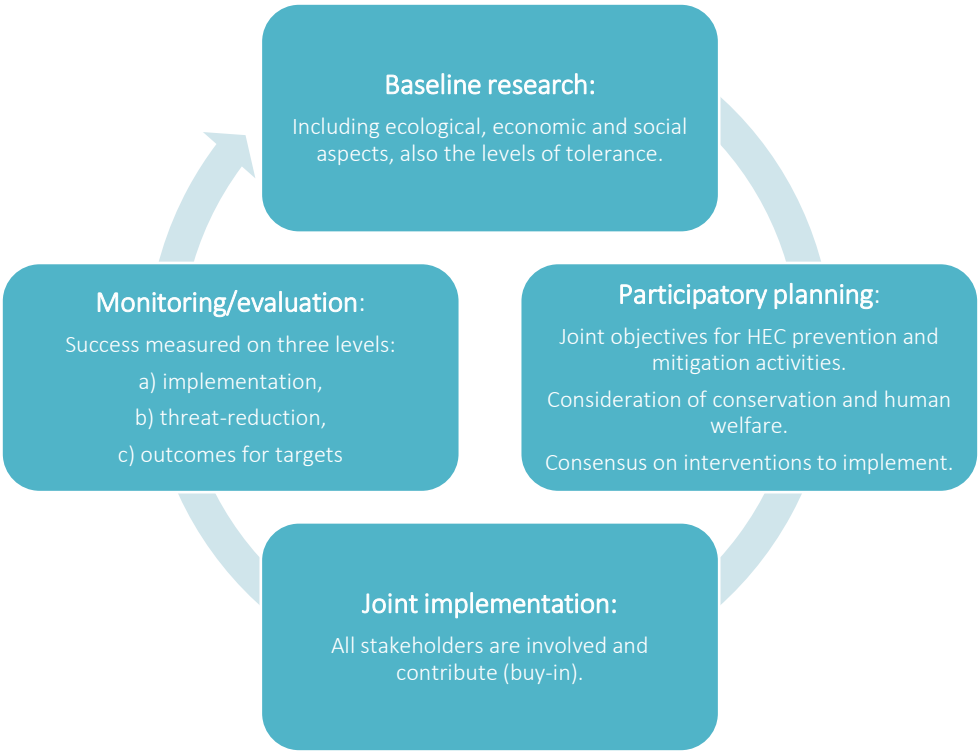

Figure 5 Step-by-step procedure for navigating the political, social, and strategic aspects of HEC management, based on Treves et al. (2007).

3.3 Financial strategies for HEC mitigation

Losses caused by elephants to the farming community include direct damage caused by trampling, feeding on crops or destruction of houses, stores or other infrastructure. Indirect costs are associated with high labour investments for guarding or the maintenance of crop protection measures and detrimental effects through guarding at night, exposure to diseases, absence from school for guarding etc. (Barua et al. 2013, Mackenzie et al. 2015). Although the majority of crop losses caused by elephants are small to medium sized damage, they can also cause very high damage, up to the destruction of a complete harvest (Gross et al. subm.-b). Furthermore, it has to be understood that even small and medium size losses by wildlife add up to general losses, due to pest insects, rodents and draught, and can play an important role in food insecurity. The call by farmers for compensation or at least an offset is comprehensible.

In case there is no benefit through the presence of elephants, the farming community will barely support conservation work, particularly those individuals carrying the cost of living with wildlife (interviewee 00J). For these reasons "*the common perception of the farming community is that elephants make poor people poorer*" (interviewee 00B).

Although conservation organisations, sport hunters and tourism may be the largest employers in many HEC areas (interviewee 00O), strong limitations are observed in income generation through the presence of wildlife. As explained by interviewee 00M, "*the current tourism model [in our area] is based on exclusiveness and hunting concessions. Local people do not have the skills to earn jobs in the high-end exclusive tourism segments. It is not showcasing the said linkage between the presence of elephants and benefits to people in the area".* Furthermore, even if income was generated through the presence of wildlife, these funds would generally be used for community development projects and not to offset losses on an individual level. Financial strategies to decrease HEC need to take into consideration a) offsetting the costs/losses by HEC and b) increasing benefits of living with wildlife.

3.3.1 Compensation of losses

Offsetting economic losses plays a major role in building positive attitudes towards wildlife and fostering tolerance towards elephants (Kansky et al. 2016). The issue of financial compensation of wildlife damage is discussed controversially and governmental compensation schemes are rarely found on the African continent. Although it is largely recognized that "*people feel they deserve to be compensated for damage or death*" (interviewee 00P) the difficulties are seen in the high administrative efforts for the monitoring of damage, fair determination of losses, and the process of payment. Besides the logistical challenges compensation schemes may be prone to corruption, particularly in case of ineffective governance.

Besides this, compensation schemes generally target the market price for victims' crops without recognition of opportunity costs of conflict mitigation and transaction costs of getting compensation, or the hidden costs of declined psychosocial and social well-being (Hoare 2000a, Ogra and Badola 2008). Furthermore, placing economic value on, and providing adequate compensation for humans injured or killed by elephants is another difficulty to deal with.

Governmental compensation schemes

Generally, the request for compensation to governmental institutions involves reporting the damage and/or loss to park officials or an authorized local body. Then, a visual assessment of the damage caused by elephants is conducted by government representatives (Table 8). In case standardized assessment guidelines are lacking, opportunities for conflict and corruption are created (Ogra and Badola 2008). The handing over of commiseration packages, when a person gets killed by elephants and/or the support for funeral costs by wildlife authorities are gestures of sympathy, which are valued by most families (interviewee 00O).

As an example, in Kenya a compensation scheme for damage caused by wildlife species was implemented in the year 2014. The value for killed livestock and damaged crops were determined by using market prices. Due to lack of consistent data, the planning had not been based on the actual numbers and sizes of damage and therefore compensation value was set unrealistically high (interviewee 00J). As a result, the number of submitted crop damage claims massively exceeded the compensation budget and no crop damage compensation was paid up to date. Payments for accidents/fatalities, however, are paid in a timely manner, thus greatly relieving the pressure to the victims' families.

Long waiting times, difficult application process (particularly for people with a low level of education) and low compensation payments are frequently heard points of criticism in areas where compensation schemes do exist. Another challenge to consider regarding compensation schemes, particularly in countries with transboundary elephant populations, is the coordination between countries. As demonstrated for different compensation schemes in the States of India (Karanth et al. 2018), conflicts can arise between the rural populations of different States and on political levels, in case of big differences in payments.

Table 8 Advantages and challenges to governmental elephant damage compensation schemes.

PROs	+ financial relief for individual losses + potential to create tolerance + decreases retaliation	CONs	- high administrative efforts - detailed monitoring needed - frequent delays - prone to corruption - losses covered partly

Community-based insurances

In case governmental compensation schemes are inexistent or failing, communal or private initiatives can give relieve to farmers experiencing severe damage. Such community-based insurance schemes are generally based on revolving funds, which ideally are filled by income generated through the presence of wildlife (Table 9). Funding agencies can also play a vital role in building up such funds. To design sustainable and sufficiently revolving funds calculations need to be based on accurate and realistic damage data. As explained in chapter 2 such data, however, are largely lacking.

In Namibia no governmental compensation is paid for losses due to wildlife. According to the HWC management plan, however, a HWC self-reliance fund can be developed within a conservancy

(MET 2018). The HWC self-reliance scheme receives a starting capital from the government and/or Game Product Trust Fund, which can be matched or topped up by the conservancy itself. As the funds are readily available on the conservancy account, quick and unbureaucratic offsets can be paid (interviewee 00C). Such community-based schemes have the advantage that the level of social control by community members is added. In case the conservancy management does not meet the expectations of the members deficits can be discussed directly and solutions can be found (interviewee 00A). In case the funds of the self-reliance scheme of a conservancy are spent, due to high level of damage by both, carnivores and herbivores, a topping up of funds can be applied for at the government level. This process, however, is described as slow and difficult for conservancies (interviewee 00F).

Table 9 Advantages and challenges to community based elephant damage insurance schemes.

PROs	+ quick process + community control + direct payment + transparency	CONs	- Game guards need to be very accurate in assessing damage - Funds are too low in areas with high HWC - In case government needs to step in, process is slow

3.3.2 Revenue sharing

Based on the assumption that the presence of wildlife can create enough income for a community to bear the costs of coexistence, revenue sharing concepts were developed.

A common concept is that income generated by PAs (e.g. through entrance fees) is partly used to contribute to community management structures. In case income generated by the PA is low and/or the administration for the money transfer is complicated, not transparent or slow, the community support gets undermined. Furthermore, community management structures themselves might be intransparent and corrupt. Improving these structures and systems in an equitable way is seen as highly important for decreasing HEC (interviewees 00H, 00J, and 00O).

Example: The conservancy concept of Namibia

Communal conservancies in Namibia are self-governing, democratic entities, run by their members, with fixed boundaries that are agreed with adjacent conservancies, communities or land owners (Table 10). Conservancies are recognised by the Ministry of Environment and Tourism (MET), but not governed by the Ministry, which does, however, have powers to de-register a conservancy if it fails to comply with conservation regulations. Communal conservancies are obliged to have game management plans, to conduct annual general meetings, and to prepare financial reports. They are managed under committees elected by their members. The conservancies employ full-time staff and are allowed to generate income from their natural resources. Joint ventures with tourism and trophy hunting operators have become important sources of income for many conservancies (NACSO 2019a). In case of non-consumptive tourism the private sector forms partnerships with conservancies to build and operate lodges and tourism ventures. They provide jobs and training to

community members, while income from these joint ventures is used to pay for conservation activities such as anti-poaching patrols, and for benefits to local communities. In case of consumptive tourism the legal hunting of wildlife according to strict quotas is used to conserve species by providing an economic incentive to keep wildlife on the land. A new approach to generate funds from local, national, and international sources is the Wildlife Credit scheme. It has started based on the number of sightings of iconic wildlife species at tourist lodges and aims at generation of income through conservation performance payments (NACSO 2019b).

However, not all conservancies have the potential to earn strong income from trophy hunting or tourism. Many are located on marginal land with little wildlife, but with a strong conservation value to Namibia. In case there are no private joint ventures available for a conservancy, tourism will not be developed and without that no income will be generated (interviewee 00F).

The income generation and community based management of Namibia's conservancies has gained high attention due to its positive wildlife conservation effects and its democratic community based process. In case of good tourism options a high potential for income generation and buffering of losses caused by wildlife, such as elephants, is seen. Revenues generated by the conservancy are generally used for community projects (e.g. construction of schools, water points, infrastructure etc.). Losses through elephants, however, occur on an individual level and are barely set off by communal projects.

Table 10 Advantages and challenges of revenue sharing in community conservancies (example Namibia).

PROs	+ whole community benefits through presence of wildlife + tolerance towards wildlife is shaped + reduction of retaliation in conservancies + strong ownership and participation	CONs	- dependant on tourism or hunting, difficulties for very remote areas - no direct offset of individual losses

3.3.3 Indirect benefits through wildlife: Sustainable livelihoods and wildlife tolerant business

Besides the creation of direct community benefits through wildlife e.g. through entrance fees, hunting concession or tourism charges, the asset of wildlife can be used in an indirect way. Market-based strategies benefitting individuals are seen as an important part of financial development schemes (Table 11). The idea is to replace farming of highly attractive crops, which at the same time are low in value, by businesses which are more suitable to wildlife rich areas and generate higher incomes. This could be achieved through the farming of cash crops which are less attractive or even unpalatable to elephants (e.g. chilli, lemon grass, turmeric, ginger, garlic) (interviewee 00B) or adding value to traditionally grown crops for the sale to lodges (e.g. beverages) (interviewee 00N). Interviewee 00N emphasized that the manufacturing and marketing of "*products from areas with a story*", or "*elephant-friendly products*" bear a viable economic perspective for HEC areas and would foster sustainable business instead of aid.

The reduction of farm-based activities in HEC areas may reduce the risk of crop losses and at the same time rise the potential for safe income generation. Successes have been achieved with

activities such as beekeeping, handicraft production, vegetables farming, and small livestock farming (interviewees 00B, 00G, 00K, 00N, and 00Q). The sale of visits to "Living with elephants' communities" or the establishment and operation of eco-community camps are further income generating opportunities (interviewee 00Q). Unrealistic expectations, however, should be averted, as tourism has failed to bring the desired income generation in many community projects (interviewee 00O).

Table 11 Advantages and challenges of implementing sustainable livelihood and wildlife tolerant business programmes.

PROs	+ safe income generation despite elephants' presence + decreases dependency on agriculture + income generated on individual level + increases resilience (income diversification)	CONs	- specific skills needed - marketing is limiting factor - direct link to conservation might get lost

3.3.4 Perspectives: Creating benefits through living with wildlife

Picture 5 "Elephant friendly" spices produced and sold in South Luangwa. © Ed Selfe, CSL

Economic factors influence tolerance towards wildlife. Furthermore, people in HEC prone areas mostly have low economic resilience. In case there is no offset to losses, tolerance towards conservation and wildlife can rapidly decline. As income generated through the presence of wildlife is generally benefitting community projects, it is unable to offset high damage caused by elephants on an individual level. Although community members may appreciate the community development activities financed by revenue sharing schemes, their individual losses are not met. This leads to the feeling of inequity.

Developing economic strategies for benefits on an individual level, e.g. through alternatives to farm-based activities, can increase individual resilience. Furthermore, offsetting individual losses should not completely be ignored, but should be considered as an important aspect in a bundle of measures. Combining community-based compensation schemes, e.g. with the condition of using crop protection measures, could motivate farmers to invest in crop protection and at the same time increase financial security.

Comprehensive and transparent schemes managed on local level and mainly funded by income generated through the presence of wildlife and coupled to the use of crop (and livestock) protection measures are giving direction for efficient HEC mitigation. Large governmental schemes, however, seem to be less effective and, thus, further increase frustration.

3.4 Technical strategies for HEC mitigation

A diverse arsenal of technical measures to prevent and decrease crop damage by elephants has been developed in the past decades. Most of these technical strategies are proposed to be used by farmers or community members across large rural landscapes, so affordability, practicality and resistance to habituation are seen as most important criteria (Von Hagen 2018). Besides the application of measures by those directly affected by wildlife damage, such measures can also be used by wildlife departments or particularly trained NGO staff. Some measures described at the end of this chapter (e.g. translocation or problem elephant control) need to be implemented in strong collaboration with or by governmental authorities.

In this chapter exclusionary and deterrent measures are described, which are aiming at keeping humans and their farms separated from elephants. Although the measures are presented individually, in practice, multiple techniques are frequently combined. Strategies may also be changed over time as elephants may test and learn to undo measures to gain access to desired resources.

3.4.1 Exclusionary methods: Fences, trenches, barriers

Separating people and wildlife species through a barrier can appear a mutually beneficial way to avoid negative impact on both sides. However, fencing can also alter people's relationship with nature. Where policy changes have constrained the movements of formerly nomadic people, fences can be perceived as symbols of the policy, generating local hostility to wildlife conservation efforts (Shaffer et al. 2019).

There are multiple ways of placing a barrier between elephants and people:

- around a protected area
- around farms and/or habitations
- around privately owned wildlife (e.g. South Africa)
- along roads to avoid collisions with vehicles on roads (e.g. Namibia/SA)
- to prevent disease transmission from wildlife to livestock (e.g. veterinary cordon Botswana)

In this report the focus is set on the first two options, as these are most relevant to the prevention of damage caused by elephants.

Electric fencing around a protected area

Barriers placed around a national park or other protected area aim at restricting the movement of elephants out (Table 12). These are permanent installations, which need to be very robust and well maintained to withstand elephants desire to move to areas they originally travelled to. Elephants are clever enough to learn to push over poles, use their tusks to snap the electrified wires, remove electric components or lay logs across the fence (Kioko et al. 2008). Well-designed heavy-duty electric fences (with electrified outriggers) can be effective deterrents, but they can be financially unobtainable or suffer from unreliable electricity sources (O'Connell-Rodwell et al. 2000, Kioko et

al. 2008). Solar powered fences, which negate the necessity for electricity obtained from a power plant, are an alternative but can be very costly. For fencing projects to be successful, regular maintenance and freedom from theft and vandalism are also necessary (Von Hagen 2018).

Although fencing probably is seen as one of the most common methods of preventing human-elephant conflicts, fencing also is considered one of the most pressing threats emerging in conservation globally (Osipova et al. 2018). The isolation of populations by fencing need to be intensively managed, otherwise populations will not sustain in the long-term due to genetic erosion (Woodroffe et al. 2014).

Fencing therefore may be a solution to human-elephant conflict on a small spatial scale but will not solve the issue at a broader scale. It may also be considered in areas where hard boundaries along a protected area already exist and long-distance movements of elephants are impossible to date. The impact of a fence to island populations of elephants, which are already fragmented due to the conversion of natural habitat into e.g. agricultural land will of course be lower than on populations which are connected through corridor landscapes.

Picture 6 Heavy duty electric fence at the hard boundary of a National Park in Kenya. © C. Thouless

It has, however, to be taken into consideration that heavy-duty fencing of a protected area will also fully restrict the movement of people into the protected area. This access restriction can be very critically seen by members of the communities living adjacent to the protected area, who may use the protected area for feeding their livestock, collecting fire wood or other resources. If not accepted by the local population fences will easily get cut through and damaged (interviewee 00V).

Moreover, fencing in one area may intensify the conflicts and overuse of habitat patches in other areas, thereby negating conservation benefits. If fencing is employed on a broader scale, then it is imperative that corridors are integrated within protected area networks to ensure local connectivity of affected species (Osipova et al. 2018).

Furthermore, fences themselves can exacerbate pressure on wildlife, as they offer a ready supply of wire, which can be used to produce snares for poaching (Woodroffe et al. 2014). Particularly in areas with a low tolerance for wildlife damage and a low support for wildlife conservation activities, the risk of increased poaching by the installation of wire fences needs to be calculated with care.

Fences need to be permanently maintained to restrict elephant movement effectively. Once elephants realise that they can cross a barrier they will be more inclined to repeat the effort. Thus the maintenance of fences must be financially and technologically within the capacities of the people maintaining them, if they are to serve as long-term solutions (Grant 2008). Maintenance

responsibility needs to be clarified before installation and has proven to be most significant for the failure or success of an electric fence.

To ensure that fences are effective against elephants Grant (2008) lists the following requirements:

- sufficient trained staff and transport must be available to ensure that fences are patrolled every day on a rotational system to effect fence repairs
- responsibilities for maintenance and costs associated are defined clearly and appropriately budgeted for
- neighbouring communities agree about the importance of fences and do not remove fencing material for their private use
- there is a reliable supply of electricity with sufficient power to deliver the required voltage

Before the decision to build a fence is taken, a detailed cost – benefit analysis needs to be conducted, also taking into consideration the maintenance costs (see Box 5). Generally fencing of wildlife should be seen as the act of last resort (Woodroffe et al. 2014).

Table 12 Advantages and challenges of electric fencing around protected areas.

PROs	- potential reduction of crop damage to zero - long-term installation to restrict access - control over all movements in and out of PA
CONs	- genetic isolation in case whole population is fenced - high costs - high maintenance - risk of vandalism and misuse - exclusive strategy

BOX 5: Special case: Fenced reserves in South Africa (Scholes and Mennell 2008)

The frequency and severity of crop damage by elephants is very low in South Africa. This is largely because in South Africa people and elephants have been separated by fences. Fences can be used to keep elephants inside protected areas, or keep them out of sensitive locations within the protected area. The effectiveness of elephant fencing varies greatly according to its design and location, and so does its cost. Electrified fences costing about 3000 to 7500 Euro per kilometre to erect, can almost entirely contain elephants (less than one elephant breakout per km per year). Ordinary game or livestock fencing has little control value for elephants.

More expensive mechanical fencing including high impact cable (e.g., Addo's 50-year old 'Armstrong fence', which is estimated to cost 9.500 Euro per kilometre to erect) can reduce this to one recorded breakout in 50 years.

Fences have a maintenance cost over the lifetime of the fence (which is typically several decades, but differs for the type of fence – electric fences have a shorter lifetime and are more expensive to maintain) of 4 to 8 times the initial cost of the fence. It has to be noted that in South Africa fences are not only erected to keep out elephants from farmlands to reduce crop damage and human fatalities, but to prevent other wildlife species from escaping, mixing with livestock, and transmitting diseases to livestock. In the South African context, the indirect costs are the main component of damage, and have added up

to a million Euros for individual disease epidemics traceable to fence-breaching, usually, but not always, caused by elephants. Averaged over the period 2001–2006, the veterinary costs of containing major foot-and-mouth disease outbreaks due to the mixing of wildlife and domestic livestock works out at 1.8 million Euros per year.

Trenches around a protected area, the example of Kibale NP

Elephant safe trenches are suitable as permanent installations, where soils are stable enough to allow deep digging and where soil erosion is limited (Table 13). The area around the trench needs to be cleared of large trees, as elephant learn to fell trees over the trenches. Around Kibale NP (Uganda) trenches have been excavated to restrict movement of forest elephants (*L. a. cyclotis*) onto adjacent farmland (interviewee 00G). The trench is excavated two meters deep and two meters wide, and the soil is piled up to form a rampart along the trench. Freshly excavated and well maintained trenches have proven reliable in keeping out elephants. Limitations appear where the topography or soil do not support the digging of trenches or where water bodies are cutting through. Elephants move along the trenches to look for crossing points. In case they find crossing points and enter into croplands, chasing them back to the PA may become difficult as the access back is blocked. However, farmers living around Kibale NP regard the trench, which is mainly paid by NP revenues, as very useful (MacKenzie 2012). The success of the trench lies in its maintenance, which can be labour intensive and costly, particularly after heavy rains.

Table 13 Advantages and challenges to the construction of trenches as elephant barriers.

PROs	+ can be constructed without a lot of materials (mainly man-power and tools) + physical barrier also to people and livestock + long-term strategy to restrict access	CONs	- risk of animals being trapped in trenches - sandy soils do no support digging of trenches - high maintenance, particularly in areas of high rainfall - topography can limit excavation of trenches.

Mobile electric fences around farms and/or habitations

In areas where habitations and farmlands are interspersed with natural habitat of elephants, such as multiple use zones like GMAs or WMAs or buffer zones around NPs, fencing off the conservation core area would reverse the idea of income generation through wildlife (Table 14). Barriers in such areas are used to restrict the access of elephants onto farms or settlements while leaving natural habitat open for free roaming wildlife. Mostly fences are used, although some habitations may be protected with permanent walls or solid barbed wire fences (interviewee 00M). Trenches are rarely used for the protection of farms. Before the installation of any fence around farmland it has to be considered that a shifting effect of damage to other unprotected areas is likely to occur (O'Connell-Rodwell et al 2000).

Solar powered fences made from wire or polywire (a polyurethane cord, threaded with strands of wire) have proven to be very effective in several sites. They, however, need to be correctly installed (earthing) and maintained. Both fence types are set up with two strands and are powered by a 12 V battery, which can be sufficiently charged by a 55 W solar panel. Such fences can cover up to 4 km and produce a minimum of 7.000 V. Slashing of vegetation around the fence is necessary to reduce the risk of leakage during the rainy season and to avoid the risk of fires burning the fence in dry season (interviewee 00B). Furthermore, trees should be removed in the vicinity of the fence to prevent elephants felling logs over the fence. The cost for one fence to protect a 1 km^2 field is calculated at approx. 350 Euros (interviewee 00E).

In Namibia the installation of a 9.5 km long permanent steel wire electrical fence around farming areas costs around 5,000 Euros. As crop damage by elephants was very high in that area, the farmers could have saved the cost of installation within 4 years (maintenance not included) (O'Connell-Rodwell et al. 2000).

In Botswana electric wire fences have proven to be very effective, where they were used around large farm clusters away from elephant corridors. Here, solar powered cat eye LEDs were attached on the fence poles to illuminate the fence at night. This added further protection to the fence (interviewee 00Q).

In Mozambique electric polywire fences were used to fence farming blocks in the rainy season (staple crop production). After the harvest had been brought in the fence was taken down and placed around villages, where the crops are stored in the dry season (interviewee 00M).

In a study conducted by O'Connell-Rodwell et al. (2000) electric wire fences had proven to be more effective than temporary polywire fences around a village. However, polywire decreases the risk of wire misuse in areas where snares are frequently used for hunting. Polywire fences can be an effective short-term solution to small farms and need to be replaced around every five years (interviewee 00E).

Table 14 Advantages and challenges of mobile electric fences around farms or habitations.

PROs	+ fence can be moved from farms to village, depending on need + additional visual deterrents can be fixed to fence + independent from electric power facility + ownership of farmers + works against buffalo as well
CONs	- scattered and spread out fields are costly to fence - maintenance is crucial - fencing of very large areas is very costly (several solar panels and batteries needed) - shifting of damage to other unprotected areas may occur - monitoring needed to avoid misuse

3.4.2 Deterrent methods: acoustic, visual, olfactory

The objective of effective deterrents is to increase the risks (biological costs) of crop damage to elephants to a level greater than the nutritional benefit (Hoare 1999, Hoare 2012). Elephants are intelligent animals, capable of learning quickly and pass on their knowledge to other individuals of the group. When exposed to these methods, elephants should develop fear and respond with flight. Ideally they should learn to avoid areas protected with deterrence, resulting in a long-term

protection effect. To achieve this, a deterrence strategy needs thorough planning and installation and will not be achieved by simply using one deterrent every now and then somewhere in a crop field. The matter of habituation of elephants against a deterrent has to be taken seriously. If an elephant is continuously confronted with a deterrent, which is unpleasant but not life threatening, and at the same time the elephant manages to gain a positive enforcement of its behaviour through feeding, the feeding success will outweigh the deterrent effect of the measure.

For this reason the use of deterrents is propagated to be used in combination and flexibly, adjusting it to the behaviour of the elephant. Such deterrent can be combined with fences (see chapter 3.4.3), but mostly they are used while actively guarding (see chapter 3.4.4). Guarding strategies need to be thoroughly revised as there is evidence that non-strategic guarding can even raise costs of crop damage by elephants (Gross et al. subm.-b).

Using acoustic (yelling, hitting metal objects), and visual signals (burning fire and lighting torches) has long been used to deter elephants from fields in combination with scaring elephants through throwing stones, burning objects and even fire crackers. Most of the guarding by farmers today is still done in this way. These measures need critical reflection and should not be propagated as "the thing to do". The reason is that if used inappropriately elephants can easily habituate or get stressed in a way that aggressive behaviour is provoked (interviewes 00B, 00I, and 00U).

The HEC toolkit by Honeyguide

Picture 7 The HEC toolkit of Honeyguide consists of four elephant deterrents, which are used consecutively (torch, horn, chilli cracker, roman candle). © Honeyguide

A toolkit of visual and acoustic deterrence was developed by the NGO Honeyguide in Tanzania and is promoted to be used in a sequential order of methods to prevent crop damage (Table 15). The objective of the HEC Toolkit is to cause elephants, over time, to react to some of the less confrontational deterrents, such as spotlights and bullhorns, thus decreasing the use of more expensive and risky measures like the fire crackers or roman candles (Honeyguide 2018).

The LED torch is the first tool to be used. Spotlights, which are shone in elephants' eyes to drive them away from agricultural fields, have also been reported to be effective to some extent from other sources as well (Davies et al. 2011). Flashing lights have been observed as effective bluffs against elephants for a short period of time, but habituation takes place easily (interviewee 00E). The air horn is ideally used together with the LED torch. It produces a very loud sound. In case the elephant(s) also do not respond to the horn, the chilli cracker is

used. The chilli cracker is produced locally from chilli powder, which is mixed with sand and filled into a condom. Then, a firecracker is tied tightly into the pack. For use the crackers are lit and thrown above the heads of elephants, taking the wind direction into account. Honeyguide advises throwing multiple chilli crackers in succession. If, however, the chilli cracker also does not show effect on the elephant(s) the roman candle is used as a last resort. A modified roman candle firework is shot into the air by a handheld launcher. It produces a series of loud explosions and accompanying extremely bright flashes. It should only be used for aggressive bulls and groups with young ones not responding to the LED torch, air horn, and chili crackers (interviewee 00I). When using the toolkit each tool is assigned to a different person, to avoid one person handling the LED torch, air horn, and chilli cracker on their own. The person using the roman candle is assigned to this job beforehand and should receive specific training (interviewee 00I).

The idea behind this progressive, stepwise approach of firstly using less stressful tools and keeping the most stressful tool as a trump card is that elephants will learn that after seeing the light they will be confronted with more and more stressful measures. Ultimately, elephants will avoid fields when they see lights, or even avoid fields completely, so that aggressive and risky tools (fire crackers) will be needed less. Honeyguide presents evidence of a strong reduction of crop damage through the use of this toolkit in Randilen WMA in the Tarangire ecosystem in Tanzania.

However, critical voices emphasize that the creation of “chronic risks” - risks which are low but permanently occurring - might easily cause habituation (interviewee 00U). The most important aspect in successful conditioning elephants in such a way that they avoid fields guarded by lights probably is that they do not get any feeding success. The moment elephants manage to feed on highly nutritious crops, despite deterrent measures taken, they will learn that it is rewarding to ignore the stressful signal.

Table 15 Advantages and challenges by visual and acoustic deterrents (Honeyguide HEC toolkit).

PROs	+ very flexible to use + relatively low-cost + can be combined with community based guarding strategies	CONs	- in case of feeding success of elephants habituation may occur - fire crackers: risk to users if used improperly - Regular higher-level training required to ensure proper use - handling of equipment is challenging and gets broken easily (interviewee 00I)

Passive acoustic deterrents

To decrease the necessity of active guarding by people at night, passive acoustic deterrents were tested, to scare off elephants from fields (Table 16). In east Caprivi trip-alarm systems were used around fields. A polyethylene cord was used to surround fields, by mounting it onto poles or trees by using U-nails. The cord was attached to a trip switch, which activated a 12 V, 10 W car siren for 10 seconds. The car siren was powered by a 12 V, 1.6 amp gel battery (O'Connell-Rodwell et al. 2000). By passing through the polyethylene cord the elephant would activate the switch and the alarm would produce a loud horn ignal. In a field test series this measure has proven to ward off

elephants to some extent, but elephants kept coming back to the fields. Instead of trip-wire systems, wireless, active infrared beam-triggered systems can be used as well. Installation costs, however, are higher and coverage may be low in case of vegetation blocking the way.

Audio playbacks of threatening sounds like wild cat growls, human shouts, and vocalizations from elephant matriarchal groups or elephant alarm calls were tested in a few studies as short-term and short-distance elephant repellents (O'Connell-Rodwell et al. 2000, Thuppil and Coss 2015, Wijayagunawardane et al. 2016). With their highly social learning behaviour elephants can distinguish between calls from different individuals. To achieve maximum success individual call recognition needs to be taken into consideration, when choosing interspecies vocalization. Furthermore, most studies were able to show that elephants quickly learn to tolerate playback sounds and return to feed on crops, particularly when no other deterrents are in place.

Table 16 Advantages and challenges of playback sounds or sirens (passive acoustic deterrents).

PROs	+ very flexible to use + low cost + does not require active guarding
CONs	- maximum extent 500 meters - short-term effect - prone to habituation

Olfactory deterrence: Chilli burning

Chilli-pepper (*Capsicum spp*.) contains capsaicin, an active ingredient which is irritating for mammals, as it produces a sensation of burning in any tissue with which it comes into contact. Elephants, with their very fine olfactory sense, strongly respond to capsaicin, which irritates their mucus membranes as well as other sensitive areas of their sensitive olfactory organ, the trunk (Osborn and Rasmussen 1995). A simple way to exhaust capsaicin into the air is to burn the dried chilli (Table 17). To ensure slow and steady burning dried and crushed chilli is mixed with elephant dung and water, pressed into briquettes and sun dried. The burning briquettes can then be placed around a field and protect the crops through the irritating chilli smoke at night. The effectiveness of chilli briquettes in alerting elephants' use of space was assessed in a field experiment in the eastern Okavango Panhandle, Botswana (Pozo et al. 2017a), for which more than 600 chilli briquettes were burned and exposed to wild elephants. The chilli briquettes were distributed 20 meters apart.

Picture 8 Chilli briquettes made of elephant dung and crushed chilli pepper, laid out for drying. © E. Gross

Results showed that elephants changed their movement behaviour in areas where chilli-briquettes were burned. Chilli-briquettes had a repellent effect when they were smouldering, but did not deter elephants in the longer term. When burning stopped elephants would come back to the same area. Chilli briquettes therefore are advisable to be used for short-term ad-hoc measures, but not as long-term strategies. Furthermore, the

burning of chilli briquettes needs to take into consideration the direction of wind, as elephants might not smell it when wind is blowing from the side they are entering into farmland.

Table 17 Advantages and challenges of chilli burning as an olfactory repellent.

PROs	+ very flexible installation + materials locally available, especially when chilli is grown as buffer crop + effective in changing elephants movement	CONs	- a lot of chilli is needed for production - many chilli bricks needed to protect a field (5 briquettes each 100 meters) - depending on wind direction - short-term measure - roofing needs to be provided in case of strong rains - chilli not grown in very dry areas

3.4.3 Deterrent fences

Seasonal or mobile fences, which are set up as low-cost physical barriers can be supplemented with some deterrent measures to make them more effective against elephants. Here the three most common low-cost deterrent fences are presented, which again can be combined depending on season, crops farmed and pressure by elephants (Von Hagen 2018). However, caution must be taken when combining fencing with active deterrent measures like scaring, beating drums etc., as this can increase damage through stressed animals at fenced boundaries (Gross et al. subm.-b).

All fences need proper maintenance and daily monitoring and the use of wooden poles may cause challenges due to availability and termites. Treatment of poles or removal after the farming season is advisable.

Metal-strip fences

Picture 9 The tin can fence produces metal sounds, when elephants try to push the fence. © Ecoexist

A simple but effective measure to protect crop fields from elephants are wire fences on which light weight, moving metal materials are attached (Table 18). This can be metal strips cut from locally available metal sheets, which are strung on binding wire (Von Hagen 2018), or beverage cans, which are similarly attached to a wire (interviewee 00Q). When the wind blows, or the fence is contacted e.g. by elephants, the strips clatter together and produce sounds. Furthermore, the strips are also reflective in the sun, and on bright moonlit nights. This provides physical, acoustic and visual signals to elephants, which have proven to be very effective during peak crop damage times, even without guarding (interviewee 00I). Furthermore, if elephants try to break the fence the sounds can alert guarding farmers (interviewee 00A). As the poles are prone to be damaged by termites they should either be treated or taken out and stored properly, during times of no farming. Metal-strip fences

need to be monitored on a daily basis to make sure wire is not misused for other purposes, such as snaring.

Table 18 Advantages and challenges of metal strip fences.

PROs	CONs
+ very flexible for installation + materials locally available + have proven effective even during peak seasons	- habituation may happen - short-term measure for guarding season - regular monitoring needed to check fence - misuse of wire for poaching may occur

Chilli fences

This fence combines the physical barrier with an olfactory repellent (Table 19). The repellent effect of capsaicin derived from chilli has already been described in chapter 5.4.2. Capsaicin is only fully soluble in oil, and researchers have discovered that it has deterrent properties when mixed with used engine oil (Karidozo and Osborn 2015).

Picture 10 A chilli fence is made from sisal ropes and pieces of cloth, which are soaked in a mixture of used oil and crushed chilli. This fence is being installed in Southern Tanzania. © PAMS

To construct a chilli fence, at first 3 m poles are placed at 5 m intervals along the field which is to be protected. Then, two strands of sisal string are strung between the poles at 2 m and 1.5 m and two small square pieces of mutton cloth measuring 30 x 30 cm are tied equidistant of each other in between consecutive poles. The chilli-oil is made from pounded dry chilli fruits mixed with used engine oil. The paste then is applied on the sisal ropes, mutton cloth and poles (Karidozo and Osborn 2015). In addition to the noxious odour, elephants must deal with moving cloths and ropes coated in irritating motor oil that must be broken through or avoided to gain entry. To date it is unknown at what distance elephants can detect the odour (Von Hagen 2018).

While these chilli fences have been found to be effective in many areas, they have been found ineffective in others (Hedges and Gunaryadi 2009, Baishya et al. 2012, Karidozo and Osborn 2015). As for many crop damage prevention and mitigation tools used against elephants proper maintenance of the measure is highly important (interviewees 00D, 00T, 00Q). The chilli-oil mixture requires regular reapplication, and farmers may abandon the method if they do not see the necessity anymore (see also Box 6). This can be anticipated through monitoring and integrating farmers into a community managed program (Graham and Ochieng 2008, Davies et al. 2011).

Table 19 Advantages and challenges of chilli fences.

PROs	+ effective for small fields and dry season + materials locally available, especially when chilli is grown as buffer crop + flexible fence + low-cost	CONs	- labour intensive, particularly in rains - farmers tend to rely on being supplied with materials for reapplication - short-term measure - environmentally acceptable disposal of used fence materials needed (old engine oil) - chilli not grown in very dry areas

Beehive fences by Save the Elephants (STE)

Playback methods conducted with elephants in Samburu/Kenya have revealed that elephants will run from the sound of disturbed honey bees (King et al. 2007). Additionally, when they run away, the elephants emit a unique low frequency "bee alarm rumble" vocalization, which warns neighbouring elephants to retreat as well (King et al. 2010). This knowledge was the basis for a new multi deterrent fence, invented by Dr. Lucy King and Save the Elephants in 2009 (King et al. 2009) (Table 20). Since then, beehive fences have gained a lot of attention and have spread rapidly. Today they are used in at least 60 projects in 18 countries in Africa and Asia (interviewee 00K).

For a beehive fence strong poles (which were treated against termites) are installed and one beehive is hung between poles every 10 meters, in such a way that the hive can swing. Then, a fence wire is installed, connecting the hives with each other, so that a contact with the fence will result in swinging hives, to which bees will react with buzzing or even leaving the hives for defence (King 2014). Any type of hive can be used for the installation, STE is generally using the Kenyan top-bar hives or Langstroth hives (King et al. 2011, King 2014). The hive needs to be protected with a little roof against direct sun light and rain. It takes about one full day to set up a fence of 300 meters (interviewee 00K).

Picture 11 A beehive fence surrounds a vegetable field close to a National Park in Kenya. © L. King, STE

The protection success of a beehive fence is determined by the occupation rate of the hives. As hives are naturally populated, the occupation rate depends on the environment (availability of flowering plants, temperature, and availability of water) and the maintenance of the hives. After having set up the fence, just before the rains start, bees will colonize about a third of all hives. Then, in the next season, half of the hives will be populated. In areas with very good population beehive fences were able to deter 80% of elephants' attempts to enter into crop fields (King et al. 2017).

Bees, which are populating the hives of the fence will collect nectar from flowering plants on the protected fields as well as in the surrounding natural habitat. For this reason, it is advisable for

farmers to grow flowering crops like vegetables, water melon, sun flowers, and any types of leguminous plants. Maize or rice are wind pollinated crops and therefore not that suitable for beehive fences. Furthermore, the application of pesticides needs to be critically reflected. In tropical areas of Western Africa the use of beehive fences along NP boundaries has failed due to high pesticide use in coco plantations surrounding the PAs (interviewee 00T).

Another limiting factor to beehive occupation is drought. Bees need water to survive and flowering plants need water as well. The arid parts of western Namibia therefore may not be suitable to beehive fences (interviewee 00F). Furthermore, great heat above 45°C will let the wax in the hives melt (interviewee 00K). For areas with low bee occupancy the replacement of every second real hive by a dummy hive can be considered (King 2014). STE is further experimenting with buzzing boxes to substitute real hives for areas with low bee occupation possibilities.

In case of high beehive occupancy the habituation effects by elephants are expected to be very low. Every time the beehives are disturbed, bees emerge and attempt to sting, creating a recurring negative association. Beehive fences might get damaged by individual elephants that did not make contact with bees before. After being attacked by bees, however, it is very likely that such elephants have learned their lesson to avoid hives (interviewee 00K).

Picture 12 Honey produced from beehives of a beehive fence in Kenya. © L. King, STE

STE also promotes simple metal cage installations against the invasion of honey badgers, which can cause large and frequent damage to the hives and destroy the honey harvest (King 2014).

The success of the beehive fence will depend on the quality of beehive and fence maintenance. A high commitment of farmers is required to properly look after the bees, detect potential problems early and to keep hives and fence in a good shape. Working with community groups owning a fence together might therefore be well thought through and depends strongly on the working relationship and attitude in such a group. Generally, it was observed that the maintenance effort of community groups was lower than that of individual households (interviewee 00K). For this reason STE does not promote beehive fences along lined boundaries, but as protection surrounding individual fields in areas with high elephant presence. Other programmes, however, have very good successes with fences owned by community groups, which are sharing their revenues from honey production (interviewee 00G).

The harvest and marketing of "elephant-friendly" honey is a promising income generating activity for many areas where people and elephants coexist. In case of well-organised sale systems the cost for beehive fences can easily be met by the income generated through the fence and even a surplus can be obtained. The beehive fence therefore is the only elephant safe fence that can pay for itself and even generate surplus income. However, some projects see a misbalance of labour and cost of this HEC measure compared to the benefit retrieved from protected crops, particularly if these crops are traditional staple crops (interviewee 00D).

Table 20 Advantages and challenges of beehive fences.

PROs	+ only fence that creates revenues + low risk of habituation, because bees are a nuisance to elephants + very suitable for flowering high value crops (vegetables, water melon, sun flowers, pulses) + pollinates crops and boosts yields + no additional guarding at night required + decreases shifting cultivation + beekeeping clubs generate enjoyable hobby interest for community members	CONs	- initial installation costs are high - high labour intensity (maintenance!) - limits in very arid areas - negatively influenced by pesticides - specific training in beekeeping necessary - less suitable for wind pollinated crops like maize or rice - less suitable for shifting cultivation, as it takes time for bees to pullulate hives

3.4.4 Combined deterrents

The combination of deterrents is advised by the AfESG and other sources (Parker et al. 2007), to avoid and overcome effects of habituation of elephants to specific measures. During different seasons different deterrents may be suitable and a variety of measures to choose from gives flexibility to the user. Here three mitigation techniques are described which integrate different deterrence levels and are very flexible in use.

Combined acoustic and olfactory: Chilli bombers

The chilli bomber is a simple device to shoot ping-pong balls filled with a chilli-oil extract against elephants (Table 21). The ping-pong balls need to be fired with strong force, so that it will reach the elephant and then break, when hitting its skin. The chilli bomber was initially designed by Mike La Grange in Zimbabwe, based on the function of a potato gun (Le Bel et al. 2010, Le Bel et al. 2013). The chilli bomber was developed further and tested for three consecutive years in South Luangwa/Zambia (Gross 2019).

The chilli bomber is made of PVC-U pipes used for borehole constructions and water installations, PVC or wooden disks and a piezo igniter used by welders. All parts are assembled with PVC-U glue or epoxy putty. The ammunition (chilli bomb) is prepared locally as well. For this purpose a ping-pong ball is filled with a locally produced, strongly concentrated chilli-oil extract.

The use of the chilli bomber requires specific training and exercise. For operation the chilli bomb is placed into the barrel from the side of the combustion chamber. Next, insect spray is sprayed into the combustion chamber for about 1-2 seconds, as explosive. The lid is closed quickly. Then, the shooter needs to target and with pressing the igniter, an explosion inside the combustion chamber

will project the ping-pong ball out of the barrel with a loud bang. The chilli bomb can be projected up to 100 meters and good accuracy of targeting can be achieved from a distance of about 30 meters (interviewee 00B). To ensure smooth operation, the chilli bomber needs to be ventilated between two shots.

Picture 13 Test shooting with a chilli bomber in North Luangwa, Zambia. © E. Gross

The ballistic trajectory of the chilli bomb is not perfectly straight, but slightly bended (like for a launcher), so aiming differs from the use of a rifle. For users of chilli bombers the dosage of the insect spray as well as the targeting need to be practiced well. It is advisable for the users of chilli bombers to work in pairs, so that one person is able to observe the elephant, while the other is loading the chilli bomber. Furthermore, the second chilli guard can shoot a second shot, in case the first shot is misplaced or not effective.

In South Luangwa the trained men all had elaborate experience in chasing away elephants from fields, by throwing stones or fire sticks, some even using a muzzle loading gun. The use of a chilli bomber needs to be based on such experiences and should not be used by untrained and inexperienced people. The users of chilli bombers should be instructed to shoot at the elephant's main body (shoulder, legs, belly, back), not at its head. Contact of the eye with the chilli oil should strictly be avoided. If the chilli ball breaks on the ground, in front of the elephant, it will still have a deterrent effect, as the elephant will smell the chilli.

In South Luangwa the use of chilli bombers was very positively perceived by the farming community and monitoring data revealed a high success rate of deterrence (interviewee 00B). Crop damage was particularly reduced when the use of chilli bombers with community based guarding approaches was combined (see below).

In Zimbabwe chilli bombers were used to chase away habituated elephants from garbage pits in an urban area. Here, however, no effect was observed (Scrizzi et al. 2018).

Table 21 Advantages and challenges of chilli bombers.

PROs	+ materials mostly locally available + materials low cost + area of use flexible + empowers local farmers + sense of security created + long-term effects possible if used in the right way + cannot be used for killing wildlife + sound different from rifle	CONs	- labour intensive - cost intensive (rations, incentives) - specific training needed

Strategic community based guarding using watchtowers

Picture 14 A trained farm guard with his chilli bomber on guarding duty together with a local farmer in South Luangwa, Zambia. © E. Selfe, CSL

Active guarding of fields is the most commonly practiced way of decreasing crop damage by elephants on the African continent. In many areas farmers shift with their families to the fields where mainly staple crops are farmed during the farming season (normally rainy season). Only elders or highly pregnant women may be left in the village. Traditionally every household protects its own field. Farming households would put up a simple temporal shelter on the ground of their field and guard and sleep there. Those fields are generally scattered in the farming area, leaving some barren land in between. As some farmers may have several fields apart and not every farming family may be able to guard, naturally, not every field is guarded. When elephants enter a field or a farming area they generally are not directly detected and start feeding. Then, when farmers finally do become aware, they try to scare them away. The elephants wander off to another field, where they continue feeding, until they are scared off again to the next field. Such guarding practices might be useful to some extent in keeping elephants away from one's own crops, but they disrupt psychosocial wellbeing and livelihood activities of farmers and they are ineffective from the collective perspective (Shaffer et al. 2019, Gross et al. subm.-b).

The strategic community based guarding approach improves the traditional guarding practice of local farmers by defining a common protection line, to which all guarding efforts are shifted. By this the complete protection of a whole farming block can be achieved through the efforts of the whole community of farmers cultivating a plot of land in a specific area (Table 22). At the strategically defined guarding line watchtowers are set up every 100 meters. Farmers take guarding shifts on the watch towers and look out for elephants approaching from the adjacent bush- or grassland. They are equipped with strong solar chargeable LED torches, mosquito nets and blankets. The moment a farmer detects an elephant, he/she will call foot patrols, who will rush to the site and chase the animal away with deterrent methods (see above). The deployment of chilli bombers in community based guarding concepts has proven to be successful in Zambia and Kenya (interviewee 00B, 00H, and 00J). The subdivision of communal land into scattered private holdings, as happening on large scale in Kenya, is undermining such systems.

Table 22 Advantages and challenges of strategic community based guarding.

PROs	+ community centred + creation of ownership + shared efforts of all members of farming community + effective if conducted properly + low cost	CONs	- needs high commitment of farming community - rearrangement of field location might be necessary - unsolved community issues may undermine success

Unmanned aerial vehicles for HEC mitigation

In 2014 it was observed that elephants reacted swiftly and dramatically to small UAVs (also known as drones) being used for aerial photography, in the Tarangire ecosystem of Tanzania (Table 23). The drones had blinking red and green lights and emitted a loud whirring noise (Hahn et al. 2016). Four types of drones were tested by Game scouts in two different areas, after being trained in a 4-days workshops. As crop damage generally takes place at night the drones were equipped with strong flashlights (2,200 lumen). Elephants generally showed flight response within one minute. Elephant groups reacted by grouping together quickly and fleeing rapidly. Game scouts were able to control the movement of the elephants through herding tactics, positioning the drone on either flank of the herd. The drone was manoeuvred with a distance of 50 to 100 meters from the elephants. Once in the air the UAV gives a very good overview of the area and it is easy to determine the direction the elephants should be guided to (interview 00S).

Picture 15 A UAV approaching a group of elephants to move them away from sensitive areas. © MEP

In 2015 one drone kit (UAV, batteries, searchlight, protection case etc.) costs 900 Euros. Including training and maintenance, it costs 13,700 Euros to equip two teams and operate the drones during the first year (excluding salaries, allowances, rations, general equipment).

The drones were also tested on driving away zebra (*Equus quagga*) or wildebeest (*Connochaetes taurinus*) from fields. However, care should be taken to understand the physiological and stress responses of each species before responsibly deploying drones to reduce human–wildlife conflict (Hahn et al. 2016).

It has to be understood that the use of UAV underlies national policies and is a tool that can only be handled by trained and skilled personnel, and therefore is most likely not ideal for community based approaches. So far UAVs have only been used by wildlife authority staff members to prevent or mitigate crop damage. As a side effect of such actions farmers may develop or support the attitude that it is the wildlife authority's responsibility to keep their field free of elephants. This might oppose the philosophy of CBC and the creation of ownership over the natural resources.

In areas where UAVs are prohibited a helicopter can be deployed for chasing away elephants, which however is much more costly and not advisable to use at night (interviewee 00S).

Table 23 Advantages and challenges of UAV as elephant deterrents.

PROs	+ very effective + flexible in use + can be used for other species as well + creates good overview in the field. + can be combined with e.g. chilli spraying in case of habituation + rapid adopting by Game scouts + positive response of farming community + reduction of risk to farmers	CONs	- cost intensive (drone and pilot) - specific training needed - not to be used by community members - dependency on power for charging - top-down approach

HEC Rapid response teams

Training experts on how to successfully drive away elephants from fields and employing them to support community members is the idea behind rapid response teams (RRT) (Table 24). Such teams are generally employed by NGOs or wildlife authorities and are sometimes affiliated with community management institutions.

A system of HEC informants is set up in the villages/farmlands to inform the HEC RRT by phone, sms or radio in which area elephants are seen. In case of clear boundaries RRTs can also be alerted by early warning systems. The HEC informants are mainly farmers who have their field in elephant prone areas. When they get aware of elephants at night, and call the RRT, elephants generally are already very close to fields. RRT generally arrive when elephants are already in the fields feeding (interviewee 00M, 00R, and 00S). To improve the response time of the RRT they can also be stationed in a particular area for several days, in case it is known that elephants are hiding in an adjacent habitat during day time.

When employing RRT the main challenges are to a) motivate farmers to properly guard and protect their fields until the RRT arrives and b) to decrease the response times of the RRTs. If elephants are not stopped before entering farmlands and have feeding success before they are chased away from a field, they will very likely return as soon as they can and over time habituate to the presence of RRTs.

Table 24 Advantages and challenges of rapid response teams for HEC mitigation.

PROs	+ support of farmers by trained experts + flexible in use + can be used for other species as well + sense of security created	CONs	- Teams generally arrive when elephants have entered farms and are feeding - high risk of habituation to human presence due to feeding success - high cost - relying on phone or radio network - vehicle needed - response might not be that rapid - short term ad-hoc measure only

3.4.5 Decreasing attractiveness

The feeding preference of elephants on staple crops or other readily available food on farmland and villages will persist, even if they are protected through barriers or deterrents. Once elephants experience the high nutrient intake by consuming such food they will be lured to crop fields or villages. Decreasing the attractiveness of farms and villages for elephants, therefore, is seen as a constructive strategy to decrease the invasion of elephants into human dominated landscapes.

Change in agriculture

In recent years it has been shown that elephants prefer feeding on staple crops such as maize, sorghum or rice (Gross et al. 2018). Protecting crops with barriers and deterrents is very labour and cost intensive. However, there are some crops, which are defended against feeding by herbivores through plant secondary metabolites. Field experiments have shown that elephants would not consume crops containing antifeedants like capsaicin (Parker and Osborn 2006) or so-called medicinal and aromatic plants (Gross et al. 2016, Gross et al. 2017). Although elephants are able to neutralize tannins with their salivary proteins (Clauss et al. 2005, Schmitt et al. 2016), other plant secondary metabolites seem to be avoided as detoxification is energetically expensive (Table 25). Such an avoidance has been demonstrated for African elephants for lemon grass, ginger, and garlic (Gross et al. 2016) and for basil, citronella, chamomile, coriander, lemon grass, mint, and turmeric in Asian elephants. The identification of such less attractive or even unpalatable crop types most probably is transmitted by olfactory cues. It has recently been shown that elephants rely on olfaction to locate food and distinguish between preferred and avoided forage (Plotnik et al. 2014, Schmitt 2016). Which odours or odour cues finally determine the decision of elephants to forage on a specific crop type or not, is still unknown. In order to develop new crop protection strategies based on odours, more research in this area is needed (Santiapillai and Read 2010).

> *"Crop selection is crucial when living with elephants."*
>
> Statement of interviewee 00K

The ecological suitability as well as market value of the grown crop has to be taken into consideration when making the crop choice for farming (Parker and Osborn 2006). Taking into consideration the local market value, lemon grass, holds high potentials as an alternative cash crops, followed by ginger, turmeric, and chilli with lower market value but high yields (Gross et al. 2016). Revenues could even be increased through value adding processes (e.g. polishing) or following standards of good agricultural practice (Booker et al., 2016).

Picture 16 Turmeric is an alternative cash crop, which is not consumed by elephants in South Luangwa, Zambia.
© E. Gross, Awely

The use of crops unattractive to elephants as a buffer between their natural habitat and rural land could be a step forward for land use planning along NPs. Particularly in highly fragmented

landscapes with patches of remaining elephants habitats, interspersed with agricultural land, like it is the case in most western African countries, the systematic planting of MAPs in rural areas, where elephants should not roam, in combination with the creation of highly attractive corridors (with highly preferred natural food plants) might be an option for reducing heavy conflicts between people and elephants.

In multi-use zones the cultivation of alternative crops should be supported through the creation of market access. Adjacent to South Luangwa, Zambia ten tons of chilli are produced annually, offering farmers a secure income (interviewee 00B). In areas of massive crop damage farming of such crops might be a viable alternative to farming staple crops. Revenues generated through the sale of crops which do not provoke conflicts with elephants ("elephant friendly crops") could then be used to purchase staple crops from areas with no HEC.

Table 25 Advantages and challenges of farming crops, which are unattractive or even unpalatable to elephants.

PROs	+ decreasing attractiveness for elephants + safe income generation without crop protection against elephants + long-term strategy + decreased dependency on risky crops	CONs	- market availability needs to be given - change in tradition takes time - farmers need to be trained

Decreasing availability of food in villages

The damage of human dwellings and food stores is a special case of damage by elephants. It appears that property damage behaviour has been intensifying in recent years, localized to specific areas. In South Luangwa, Zambia it was shown that mean costs of property damage even exceeded crop damage costs, suggesting that this topic needs to receive greater attention (Gross et al. subm.-a). Studies in Zambia and Zimbabwe have shown that it is mainly single or pairs of male elephants showing this high risk behaviour (Scrizzi et al. 2018, Gross et al. subm.-a). In Zambia, elephants are searching houses for stored maize in the dry season, in Zimbabwe they are feeding on garbage in the roads of towns. As mentioned in Box 4, fear and the perception of danger strongly influence human attitudes. The shocking experience of losing one's home and shelter during the night, very probably has influenced the attitudes towards both elephants and the institutions taking care of their conservation, in a negative way. Offering quick support to these people is highly important for the possibility of the coexistence of people and elephants to be achieved (interviewee 00B). Furthermore, the prevention of such incidences needs to be taken into serious consideration. The reduction of access to easy food, as well as the reduction of olfactory emission of attractive food smells from villages, could be a key to prevent property damage. To reduce the risk of people being killed during property damage events at night, the separation of stored food away from the houses, obviously, is an important measure. Cultural and traditional ways of housekeeping, however, need to be taken into consideration.

Picture 17 A concrete elephant safe food container constructed in a village close to Luambe National Park, Zambia. © E. Gross

Changing the habits of food storage involves traditionally applied measures, which create a greater benefit or additional asset. In the Luangwa valley, Zambia so called elephant-safe food containers are supported by several NGOs and are appreciated by the farming community (Table 26). For this a traditional grain store was modified by using concrete instead of mud for construction and by adding a heavy lid and a small door opening, whilst still maintaining the traditional shape (Gross and Banda 2015). As the store can be locked, the stealing of crops can be prevented, not only by elephants, but also by neighbours. A simple thatch roof protects the container from strong rains. The costs for a single store, which contains enough maize for a household of eight people for a year is about 80 Euros, without labour costs and tools (largely depending on price of cement).

Methods to protect crops against elephants can also be combined or modified, for example through the application of chilli soaked cloths (see also Chapter 5.4.3) on single traditional granaries or the construction of a small chilli fence (Chapter 5.4.3) with just four poles and four pieces of chilli soaked cloth.

Furthermore clean-up of settlements and the location of safe garbage pits outside habitations may reduce attractiveness to elephants (Scrizzi et al. 2018)

Table 26 Advantages and challenges for construction of elephant-safe food containers.

PROs	+ elephant proof storage of staple crops + safe against theft + similar to traditional way of storage	CONs	- high construction cost for this target group - not mobile in case of shifting - needs maintenance - treatment of maize against weevils needed - maize needs to be perfectly dried for storage

3.4.6 Securing water points

In arid areas, crop damage by elephants plays a minor role as farmers are mainly pastoralists. Here, HEC is more prone to water points, at which installations may get damaged by elephants or because of competition between livestock farmers and elephants at open water sources.

Installation of safe water points

In arid areas, where water is pumped from underground by wind, solar or diesel powered engines the water is stored in large plastic containers. In search of water elephants can damage these water containers with their tusks or damage pumps and pipes to get access to water.

Picture 18 A water point secured by a stone and concrete wall in Namibia. © EHRA

To avoid such damage, the construction of elephant proof walls around water points can be highly effective, if construction is done properly (interviewee 00F) (Table 27). The water pipes need to be completely cemented in as well and the pump needs protection. To decrease the pressure by elephants on the installation, ideally some water from the borehole is provided a bit further away to elephants. Due to the large amount of cement needed, the construction costs of such protection measures are costly and a high number of water points is needed to be secured in large areas (interviewee 00F).

In Namibia the replacement of wind mills to pump the water by new diesel engines has fostered HEC. As diesel is expensive, people now do not want to waste a drop of water to wildlife and avoid sharing the resource water with elephants. Through the introduction of diesel pumps a financial loss is created, in case elephants "steal water" (interviewee 00C). This problem could easily be solved by the use of solar instead of diesel pumps in elephant habitats.

Table 27: Advantages and challenges of the installations of safe water points.

PROs	CONs
+ very effective if done well + ideally provision of water to people and separately to wildlife + takes a lot of pressure from people	- high construction cost - need for many installations

Separation of water supply for elephants and people/livestock

Particularly during dry months, HEC can occur at open water sources, which are used by both, elephants and people at the same time. Here human fatalities are a major concern (interviewee 00I). The provision of alternative water sources for elephants or people are easy solutions (Table 28). Water sources for elephants can simply be provided by digging out sand from natural water holes, as sanding-up is the most common cause of disappearing water holes (interviewee 00I). If provided at strategic places (e.g. inside PA, close to anti-poaching camps), the creation of water points for elephants can provide further safety to elephants and separate them from human habitations (interviewee 00I and 00F). The provision of water to elephants, however, has to be well planned by taking into consideration ecological data on natural elephant movement patterns and availability of vegetation, as artificial water provision can have detrimental effects to sensitive ecosystems (Smit et al. 2007).

Table 28 Advantages and challenges of the separation of water supply for elephants and people.

PROs	+ rectifies conflict over water + safer water provision for people + keeps elephants stronger inside PAs
CONs	- influence on ecosystem has to be taken into consideration - high cost of maintenance

3.4.7 Early warning systems

The detection of elephants in specific areas to warn farmers about their presence is the idea behind elephant early warning systems (Table 29). Once detected, safety measures can be taken or deterrents can be prepared, before elephants have reached crops or habitations. The simplest early warning systems are watchtowers with guarding farmers or trip wires. The early warning systems presented in this chapter include measures which can potentially cover larger areas and may develop further in the future.

Satellite tracking and geofences

Data collected on elephant movements via radio or satellite collars are helpful for understanding movement patterns and habitat selection of elephants. Such data give a highly valuable insight into areas that may be prone to crop or property damage and allow analysis of changes in movement patterns over time and with changing ecological and anthropological factors. The collaboration of research on elephant movement and programmes working on HEC mitigation needs to be fostered to enhance synergism between these fields. The working group on HEC and elephant movement in the KAZA region is an example for such important networking (interviewee 00Q).

Furthermore, satellite real-time tracking of collared elephants can facilitate early warning of potentially problematic elephant individuals and herds (Venkataraman et al. 2005). Such systems are conceivable in case individual elephants were identified for causing a majority of losses (e.g. house damage in villages) and in areas where elephant numbers are manageable.

A further development of satellite real-time tracking is the installation of so-called geofences. Geofences are spatial shapefiles which are programmed into the collars of elephants. The moment an elephant crosses the programmed boundary of a geofence an alarm will be sent to a central point, where response will be coordinated. The first geofence was erected in Ol Pejeta conservancy, Kenya, in 2006 to respond to notorious fence breaking elephant individuals (STE 2019) and has been further developed in the Kenyan Mara (MEP 2019). Despite great achievements in real-time tracking of elephants, we are still far from a “remote control” of elephants. The response to alarms still needs to be done manually and is risky, labour and cost intensive.

Furthermore, the value of geofences in HEC prevention is still limited due to the initial challenges of capturing and collaring elephants, the requirement of internet connectivity or network coverage to transfer alerts and considerable subscription costs of regular data transfer (Shaffer et al. 2019). However, technical developments and improvements may open new doors to sophisticated and high-tech HEC prevention systems.

Infrasound detection

Elephants do not only communicate by rumbles and trumpets but also through very low frequencies which are considered as infrasonic sounds. Such low frequencies of sounds travel longer distances than their audible counterparts. Therefore, infrasonic emissions from wild elephants can open a new option for detecting and locating them over a longer distance, up to 500 metres (Dabare et al. 2015). The placement of detectors at conflict-prone locations to monitor infrasonic calls may enable detection and localization of individuals over long distances. To date, however, autonomous early warning system for elephant presence, based on infrasonic waves are not yet operational. Challenging is the precise detection of elephant sounds, particularly in noisy wildlife ecosystems (Zeppelzauer et al. 2015). Further research and development efforts are needed until affordable and reliable systems can be used in the field.

Hotlines and farmers alerts

Once elephants are detected, the message has to spread. The use of mobile phones for quick communication among farmers and between farmers and local officials to drive away elephants has been widely established in areas with mobile phone network coverage (Graham et al. 2011). Also the use of mass SMS or other messaging systems to alert certain target groups has shown good results (Le Bel et al. 2014, Le Bel et al. 2016a). Where radio network is available, the use of radio jingles for safety warnings to inform people where elephants are moving to (e.g with the onset of rains) are used (interviewee 00E and 00R).

Table 29 Advantages and challenges of early warning systems against elephant invasion into human dominated landscapes.

PROs	+ fosters collaboration between research and conservation + ideally elephants are moved away from unsafe places before causing damage + supports real time observations + enables quick response	CONs	- high cost of installation - knowledge of technology required - phone/internet connection required for quick response - link to farming community difficult - implemented as top-down approach

3.4.8 Removal of problematic elephants

So-called problem elephants, which have habituated to human presence, have learned where to find highly nutritious crops and have undone crop protection measures may have to be removed from an area as a last resort.

Translocation

The translocation of such individuals is widely advocated by animal rights groups (Table 30). The translocation involves drugging, immobilization, and transportation of individual elephants or groups of elephants from human settlements or farms to PAs for release. This process is very expensive as it requires skilled personnel and specialized vehicles to move the animals (trucks, cranes, helicopters). The identification of the correct problem elephant(s) is often very difficult. Besides this it is very difficult to find relocation sites that will accept the animal (Songhurst 2010).

The efficacy and long-term feedbacks of elephant translocation have not been extensively tested, but initial results suggest that translocated elephants often return to their original territory and tend to propagate conflict around the release area while returning toward their original home range (Pinter-Wollman 2009, Fernando et al. 2012). The increased mortality of elephants during capture and transportation also has to be taken into consideration, as this might undermine conservation goals.

The mass translocation of about 336 elephants in Malawi from Liwonde NP to Nkhotakota Wildlife Reserve in 2017 created a high awareness of the translocation topic. Here, the restoration of a reserve, which had its elephant population nearly completely wiped out by poaching, was the main driver for the translocation. The reduction of severe HEC around Liwonde NP was another positive side effect of that management decision (interviewee 00P).

Table 30 Advantages and challenges of the translocation of problematic elephants.

PROs	+ favours animal rights perspectives + removes PE without killing	CONs	- high cost - skilled personnel needed - specialized vehicle needed - difficulty to identify correct PE - availability of suitable relocating sites scarce - high mortality during capture and transportation - gap will most probably filled by other elephants

Problem elephant control (PEC)

Elephants with recurring behaviour of damaging crops or entering villages, or those that have become habituated to mitigation techniques are sometimes culled by wildlife authorities to reduce HEC and to appease farmers (O'Connell-Rodwell et al. 2000) (Table 31). Besides being controversial (Aarde et al., 1999), culling can be ineffective, as another elephant will commonly replace the removed individual and culling can negatively impact family structures (Archie and Chiyo 2012, Chiyo et al. 2012, Shannon et al. 2013).

Similarly as for translocation the identification of the individual displaying problematic behaviour is difficult, particularly if a fatal accident happened unwitnessed or at night. The risk to shoot the wrong elephant can be decreased through the implementation of a good monitoring scheme, prior to the PEC, which is taking into consideration individual elephant identification. This, however, is labour and cost intensive (see Chapter 2).

PEC is strongly favoured by many communities as they can utilise the meat (interviewee 00B). Elephant meat of shot elephants is consumed in many African countries, such as Zambia, Zimbabwe and Botswana. This method takes the pressure off the wildlife agencies for a while, but can lead to the mixing of interests. The decision making process on PEC becomes susceptible to wrong decisions, if the distribution of meat ranks higher than finding the correct animal with problematic behaviour. Furthermore, communities are encouraged to claim for elephants being shot, because of need for meat. It has also been reported that department officials prefer this strategy

as they will be the ones to collect the best pieces of meat (interviewee 00B). In case PEC is chosen as one of the HEC mitigation strategies a sober and clear decision scheme needs to be put in place that does not give room to corruption (interviewee 00U).

PEC should be seen as a last resort for elephants displaying very problematic behaviour. It, however, has to be taken into consideration that taking out one strongly habituated animal will most probably result in a different elephant taking the niche (Chiyo et al. 2012) as knowledge has already been passed on.

Table 31 Advantages and challenges of Problem elephant control

PROs	+ PE removed + type of intervention favoured by most community members + wildlife agency can demonstrate good will + meat can be consumed by victims	CONs	- short-term effect - disturbance of elephants' social system - sensitive to corruption

3.4.9 Perspectives: Being ahead of elephants

A diversity of measures to prevent damage by elephants or to mitigate them has been established and several strategies are still under development. However, when talking to HEC managers it becomes obvious that "the one" crop protection strategy does not exist. It is emphasized that measures might work successfully until a certain point, and then fail. To avoid wrong interpretations about the failure more emphasis should be put into understanding the limits of crop protection measures against elephants and the correct communication about it. Therefore, in the first place, HEC mitigation measures should not be promoted as solutions (interviewee 00U), but as options for which the ecological, social, economic and cultural setting needs to be understood.

The habituation of elephants to threats and their ability to learn and undo measures requires the use of multiple measures and a close monitoring of habituation effects. Effective strategies require understanding the behaviour of elephants and the effort of always being a step ahead of them. The first and most important principle in effective crop protection is to not let elephants get a bite (Interviewee 00N and 00U), because the moment elephants feed on crops positive enforcement and learning happens. For this, strategies which are based on elephant movement patterns and behaviour need to be developed. Flexible and variable, crop protection systems on communal lands need to be low-tech and available to the affected community. Response to elephants need to be quick and effective to show long-term success (interviewee 00S). Furthermore, the reasons for damaging elephant behaviour need to be understood. If natural forage and water is sufficiently available, elephants are more easily deterred from crop fields. However, when elephants are forced into starvation or are lacking salt, minerals or water, the deterrence will be much harder (interviewee 00K). Whatever the reasons, once elephants have

"In many cases programmes have trained elephants to become effective at avoiding or dealing with interventions. And this is the worst thing we can do."

Statement interviewee 00U

managed to feed on the desired nutriment despite a mitigation measure in place, this measures has most probably lost its deterrent effect to that individual.

A rigorous crop protection strategy to avoid HEC should include well-informed, evidence-based PEC. Instead of using PEC as a retaliation or indirect compensation, PEC needs to be used strategically, to avoid severe losses and learning effects in the elephant population. Interviewee 00U reflects that "*maybe PEC has to be considered at an earlier stage, before knowledge has been spread to other individuals and to avoid even more elephants to be shot at a later stage*".

A major challenge for HEC mitigation is the constant attractant of ripe crops to elephants. Stopping elephants' movements to attractive crops will always be labour and resource intensive. For a long-term coexistence new ways need to be found, strategies need to be reviewed and rigorously evaluated in terms of cost and benefit. Taking attractive crops out of the way of elephants (00O), developing alternatives to farm-based activities (interviewee 00I) and promoting the farming of crops unpalatable to elephants could start a paradigm shift from the fight against elephants to a more balanced coexistence.

Having understood the elephant side of the problem, the human side needs to be taken into consideration as well. Mitigation measures need to suit the culture, tradition and habits of the farmers. If a measure is highly appreciated by farmers, because they regard it as effective, it already works into the direction of shaping tolerance (interviewee 00Q). Measures, however, that have proven to be highly effective in one area may not be suitable in a different cultural setting.

BOX 6: The problem of maintenance

Most technical HEC measures strongly depend on adequate maintenance. This maintenance generally is to be conducted by specific members of the farming community. In all HEC programmes in Africa the issue of a maintenance breakdown is observed (interviewee 00U). This maintenance breakdown is characterized by initial high motivation for the implementation of the measure and the commitment for maintenance, and a drastic decline in maintenance efforts over some time. The problematic point seems to be that only if the benefit of maintaining a measure is visible, high input by community members or individuals is given. However, when the measure shows success the damage ultimately declines and with that seemingly the stimulus to remain active. The benefit is not visible anymore (e.g. because elephants stop coming) and maintenance input goes down (interviewee 00K). If then damage happens because of low maintenance, it is claimed the measure was not working. Besides this many technical HEC measures require strong labour input. In case of relatively low expected benefits (e.g. the regular harvest of a staple crop), motivation for extra work might be low.

Here a need has been identified for the development of approaches to maintain the motivation for maintenance of successful measures. Keeping the personal connection to users, constantly monitoring their activities and success and regular communication about challenges and perspectives seems to be one option to achieve this goal (interviewee 00B).

3.5 Spatial management for human-elephant coexistence

When trying to find an answer to the general question on whether elephants and people can coexist, the spatial scale has to be taken into consideration. Currently people in 37 African countries are sharing their land and resources with elephants. In some areas fragmented populations of elephants remain in isolated NPs, strongly separated from human activities. In other areas multiple-use zones provide habitat for elephants and space for people in a land-use mosaic. As elephants are fond of staple crops, compete for water resources and may have learned to search for food in houses, a separation of people and farming activities at fine spatial scales is necessary to avoid damage. If solutions for a separation are found at these fine spatial scales, a coexistence at large spatial scale may become possible (Table 32).

The basic requirement for the separation at fine spatial scales is to understand the needs of elephants and the needs of people.

3.5.1 Identification of elephant pathways, needs and corridors

In the past 50 years research has revealed insight into the complex behaviour of elephants (Moss 1983, Lee and Moss 1986, Douglas-Hamilton 1987, Archie et al. 2006). Particularly movement data of elephants throughout the seasons is fundamental, when defining core habitats and corridors. Collaring elephants and tracking their movements is a method to visualize this and the use of collar data is an important tool for conservation planning (interviewee 00Q). A strong emphasis has been put on understanding and designing connectivity of elephant habitats, to ensure movement and genetic exchange (Thouless 1995). Furthermore, maintaining the connectivity of habitats bears the potential to reduce the intensity of HEC (interviewee 00O).

> *"Elephants are surprisingly resilient. Actually all they need is space to move."*
>
> Statement by interviewee 00K

Although elephant corridors have been described for many areas, they often only exist on paper (interviewee 00E, 00N, and 00Q). Once connectivity corridors are populated by people, massive problems may arise in the future, particularly if growing elephant populations are to move through these zones. Protecting crucial corridors for elephants also means preventing the creation of new HEC areas. In case corridors are not properly protected and people living in its vicinity are not bound into economic strategies, education and HEC management programmes, there is a high risk that such areas become sinks for elephants. Elephants wandering off from protected areas into vast unprotected corridor landscapes may easily become targets for poaching. It is therefore important to not only define corridors and keep them free of settlements, but also to create proper management systems to ensure safe coexistence of people and elephants in such areas.

Transparent communication and equitable participation of local stakeholders is indispensable for the land-use planning of corridors, also to prevent the creation of mistrust and the impression of "green grabbing" (Benjaminsen and Bryceson 2012, Fairhead et al. 2012).

Without doubt, corridors are crucial for thriving elephant populations in many African landscapes. However, it must not be forgotten that in the first place safe, large contiguous elephant populations

need to be established and maintained. For small elephant populations in very isolated habitats corridors might not be the solution, as the exchange with other populations may become unrealistic (interviewee 00U).

3.5.2 Identification of people's needs and land requirements

In multiple-use zones and areas adjacent to national parks people make their living. Some have inhabited these areas since decades, some have been shifted from protected areas, some have moved into these areas recently in search for land and jobs. Whatever the reasons may be for people living in or adjacent to protected areas, it is uncontested that they have a right to do.

Picture 19 Community stakeholders identifying HEC hot-spots in a participatory planning process in Zambia. © E. Gross

Identifying the needs of the people sharing their land with wildlife is a crucial first step for a participatory land-use plan. It has to be understood which requirements people have regarding land and resources, taking into consideration traditional land-use practices, cultural bonding, beliefs etc. This process may take time as mostly communities do not readily know what they exactly need now and in future and the community itself may not be a homogenous group. Different people may have different desires and attitudes. Starting a professionally mediated process of defining land requirements and agreeing on development goals will help defining the needs for space and potential for income generation and development. It is advisable to not only discus the spatial requirements but also the details of use. Farming areas for example can be used in multiple ways, for the cultivation of traditional staple crops in shifting cultivation or by means of conservation farming with improved soil protection or by farming unpalatable cash crops. Farming areas close to corridors or elephant refuges will either need strong protection or farmers should consider the cultivation of unpalatable cash crops. Ideally, a land-use plan based on a participatory community process should take such usages and details into consideration. Only then it may guide community members to sustainable land-use practices.

The following farming practices have been identified by interview participants to decrease the likeliness of damage by elephants:

- Block agriculture instead of spreading and shifting (interviewee 00M).
- Improvement of agriculture, soil protection, conservation farming to achieve more yields on smaller space and decrease shifting (interviewee 00Q).
- Development of permanent settlements, improved and safe housing (interviewee 00M).
- Production and protection of value added crops (interviewee 00Q).
- Cultivation of crops unattractive to elephants (interviewee 00B).

3.5.3 Perspectives: Creating a landscape for people and elephants

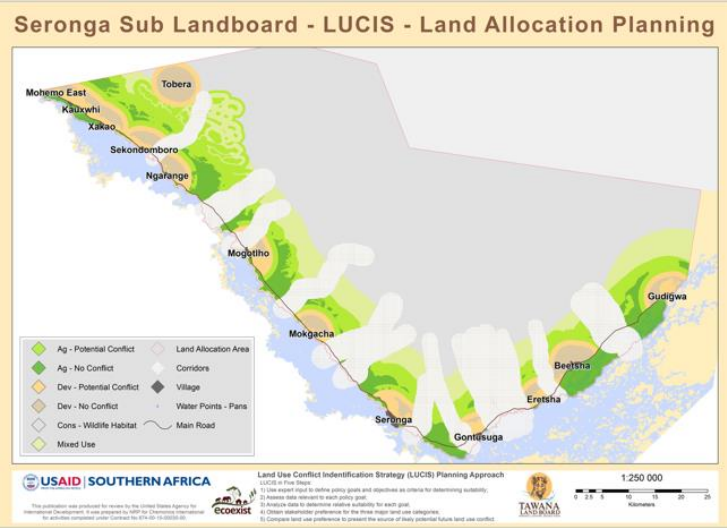

Figure 6: Map of agricultural (green) and development zones (brown) and the location of elephant corridors and HEC risk areas in the Eastern Okavango Panhandle, Botswana. © Ecoexist

The challenge of coexistence is to use and manage a landscape in such a way that people find safe space and ways to make their living, and elephants find safe space to thrive. Land-use planning facilitating human-elephant coexistence needs to identify which areas are suitable for farming staple crops or less attractive cash crops, where settlements can be safely located, how to protect farms and settlement. Interviewee 00U explains that such areas should be defined as "no go zones for elephants", with clearly identifiable demarcations for elephants. At the same time, contiguous habitat and corridors need to be identified, which meet the requirements of a thriving elephant population. Overlaps of these defined areas for people and for elephants and competition for resources should be circumvented. In case overlaps cannot be completely avoided (e.g. through the location of roads), risky areas, which need special attention, need to be defined. Finding the balance between connectivity and strict boundaries is challenging but seems to be the way forward for creation of coexistence at large spatial scale.

The most important part of the spatial management of a safe landscape for people and elephants is the implementation on the ground. Truly participatory approaches are required to enable planning based on understanding and acceptance. The potential of a planning document will only unfold if all stakeholders of the region agree on it and contribute to its implementation.

Table 32 Advantages and challenges of participatory, local land-use planning.

PROs	+ long-term effect + potential for sustainable development + participatory approach + involves economic and social aspects
CONs	- long process - requires skilled facilitators - high cost - effective only when all stakeholders are involved and process is carried out professionally

BOX 7: The SAFE System approach designed by WWF

Figure 7: Safe Systems Logo by WWF

The SAFE System approach was developed within the Tigers Alive initiative of WWF to create a holistic approach to decrease livestock attacks and human fatalities caused by tigers while achieving a growing tiger population and taking into consideration growing human populations. The idea was derived from the complex transportation sector, as every traffic accident is completely unique, and there are often fatalities, which make it emotional. Historical trends in traffic fatality management have shown that increases in vehicle numbers can be decoupled from the number of fatalities through a sole focus on safety.

Similarly, the SAFE System approach divides the HWC system into four parts: the people, assets, habitats and wildlife. The system encompasses a structured process that delivers a suite of actions appropriate to a site toward a single long-term goal for an area: to make it safe. The SAFE System approach is based on the experiences that were gained in the past on how to make each part of the HWC system – the people and their assets, wildlife and habitats – safe. And if each of these is made safer, then the overall area becomes safer and HWC is minimized.

The SAFE System approach defines six elements of conflict: mitigation, monitoring and evaluation, policy, prevention, response and understanding the conflict, which are all addressed. A rapid assessment is used to capture the level of coverage across each of these elements. In this assessment the level of coverage for the safe person, safe assets, safe wildlife, safe habitats and monitoring is calculated, based on detailed sets of criteria and summarized in a spider web chart. This shows very comprehensively which parts of the system need to be scaled up to gain overall safety.

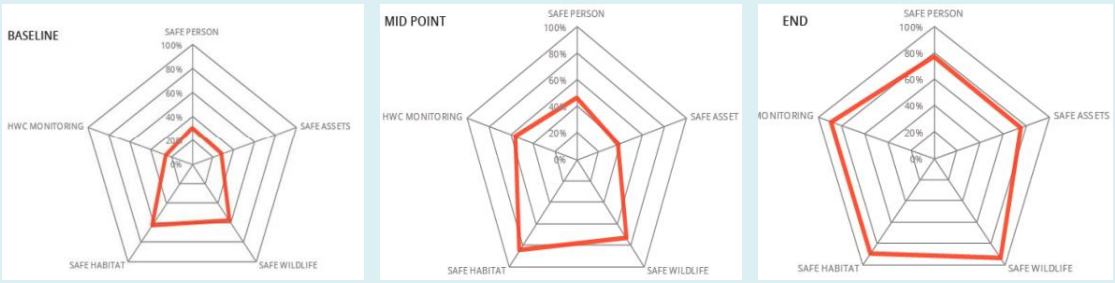

Figure 8: Exemplary progress from baseline to end with the implementation of SAFE systems strategy, visualized by spider web charts showing the levels of coverage of all five elements of HWC © WWF


A future for elephants and people
© E. Gross

4 The future of elephants and people: Requirements for coexistence

4.1 Lessons learned from the field

Interviews with 23 HEC managers of 12 African countries have given a deep insight into on the ground experiences around HEC. The interviewees were questioned about their important lessons learned when dealing with HEC, needs they face and conditions they regard as essential for the future of people and elephants. They have shared an enormous diversity of experiences and insights, which were clustered and presented in the following section.

Firstly, HEC is seen as a symptom, not a cause (interviewee 00P and 00U). Habitat loss and the arising competition for land and resources as well as other economic, political and social factors are seen as causes and drivers for HEC. In general it is understood that the problem of HEC cannot be wiped out completely (interviewee 00I and 00T). There will always be some risk of crop and property damage and negative perceptions by individuals. However, the risk of HEC to arise must be reduced to a tolerable level (interviewee 00H).

HEC is a highly complex phenomenon with many levels involved (political, community, social, family, financial, tradition, culture, ecology) (interviewee 00Q) and is strongly dependant on the context (interviewee 00L). Simple solutions therefore are not to be expected and learning about HEC needs to continue (interviewee 00L). Due to its complexity holistic approaches are needed, which understand and tackle the problem from all sides (interviewee 00Q) and CBC is generally seen as the only way forward (interviewee 00A, 00B, 00N, 00O, 00Q, and 00T).

Lessons about the human dimension in HEC

As there are many different stakeholders involved in HEC (interviewee 00C), every single of them needs to be included in HEC mitigation management strategies, such as community boards, civil society, government, NGOs (interviewee 00A). The needs of the local people have to be identified (interviewee 00G) and taken seriously to build up a trustworthy relationship (interviewee 00C). When working together with all stakeholders ideas can be exchanged and combined, so that problems, which seemed to be unsolvable, can finally be solved (interviewee 00G).

> *"Only the community itself holds solutions for the future."*
>
> Statement by interviewee 00O

The involvement of local communities into HEC management in a strong participatory way seems crucial for achieving a peaceful coexistence of people and elephants (interviewee 00Q and 00L) or as interviewee 00B puts it: "*If we are going to make any headway, it is by going through the hearts*

and minds of the community". Interviewee 00N emphasises: "*Conservation will never make progress if we don't stop working against local people*".

As trust building takes time, participatory community work needs long-term presence (interviewee 00L); short-term and ad-hoc activities are bound to fail. Involving communities in HEC mitigation practically means relevant capacity building and equitable empowering (interviewee 00N). When people perceive ability to control the environment, stress is reduced and tolerance is increased (interviewee 00U). An important focus should be set on environmental education to make people understand where farming is safe and where not, and how to react when elephants are coming (interviewee 00V).

Taking community concerns seriously further means being present and contactable for farmers and to timely react on their needs (interviewee 00C and 00E). "*There need to be people available to talk to farmers facing damage, they need to be recognized, not to be left alone with losses*" explains interviewee 00A and interviewee 00G adds: *"[We need to] do our jobs in the community with passion"*.

To create sustainable long-term strategies, "*revenues generated thorough wildlife should be used to reduce HEC*" explains interviewee 00A. Revenue shares could e.g. be used to fuel community-based HEC insurance schemes. Furthermore, stronger focus needs to be set on the development of wildlife friendly business and income generation activities (interviewee 00D, 00N and 00R) as well as the equitable sharing of revenues generated through tourism and hunting (interviewee 00H, 00Q 00R, 00T). A step further is the creation of ownership over wildlife with direct benefits and decentralized responsibilities (interviewee 00E).

Lessons learned about elephant behaviour in HEC

The importance of maintaining contiguous habitat, securing access to water and protecting habitat connectivity is seen as the crucial aspect for elephant's survival in the future (interviewees 00A, 00B, 00C, 00K, 00L and 00T). Although elephants have complex family structures and learning behaviour, "*it is quite predictable what elephants do and damage is not caused at random*", explains interviewee 00E. This knowledge should be used more specifically in HEC mitigation strategies (interviewee 00E). In many areas elephants damage crops just because of their availability, not because they are forced to do so (interviewee 00U). To reach the desired crops they will use their intelligence to circumvent measures (interviewee 00J and 00M). The need to learn more about spatial requirements of elephants in human dominated landscapes, however, is highlighted well (interviewee 00U). Also understanding drivers of HEC need a lot more attention (00U).

> *"Corridors and connectivity needs to be secured, even if elephant populations currently are low."*
>
> Statement by interviewee 00E

Another aspect to take into consideration seems to be large differences in response by elephants to humans and mitigation strategies in different areas. As "*some elephant populations are peaceful by nature*" (interviewee 00M), other populations seem to be easily stressed (interviewee 00K, 00N).

Experiences elephants have made in the past with humans and the influence of heavy poaching on their social structure may lead to unusual behaviour (Bradshaw et al. 2005, Bradshaw and Schore 2007). Interviewee D and V emphasized that measures to deter elephants should not be too active, as "*elephants might get aggressive and take revenge at another occasion*". Against this observation stands the insight that elephants can easily habituate (see page 69*f*.) to measures, particularly if they are no real risks (interviewee 00U). Using a variety of methods and vary them through the seasons rotationally will keep elephants unaware about what will happen (interviewee 00K) and therefore seems to be a good way forward.

4.2 HEC management recommendations

Assuming the recent poaching crisis was solved, HEC is likely to rise again. Governmental and non-governmental institutions, therefore, need to get prepared, before farmers unnecessarily suffer big losses. Responsible institutions, however, are facing real constraints in terms of HEC mitigation strategies and particularly need to build up on capacity, skills, structure and training.

> *"HEC currently is something we react to and not something we really try to understand and manage, this needs to change."*
>
> Statement by interviewee 00U

Although the reduction of HEC has made its way into several national elephant conservation strategies there is a lack of management oriented national action plans for HEC mitigation, ideally including community-based measures and definitions of roles, responsibility and structure. This is a shortfall that urgently needs to be addressed. Firstly, however, political will is required to work into the direction of long-term coexistence of people and elephants. Changes in legislation to provide a stronger role of responsibility for communities might have to be considered as well. Accountability, governance and transparency of wildlife and community management institutions are fundamental in this process. Furthermore, strong capacity building in designing, planning, implementing and monitoring effective HEC mitigation strategies and guiding participatory community conservation endeavours is needed in wildlife agencies and NGOs. Depending on the developed strategies adequate budgets for human resources, logistics and working-infrastructure need to be allocated.

The lack of coherent HEC data collection makes monitoring and evaluation difficult, which again may lead to wrong assumptions on success or failure of measures. A well designed and managed HEC and elephant movement monitoring system, based on community involvement, may be the way forward. Transparent sharing data on HEC and elephant movement (within data safety requirements) among landscape stakeholders and on transboundary level would greatly enhance trustful relationships and understanding. Monitoring also has to include habituation effects of elephants as these are the highest risks for HEC measures to become ineffective. Finally, a HEC management system including real time and elephant movement data harmonized into one monitoring application would facilitate well-informed and evidence-based decision making.

Furthermore, HEC management needs a paradigm shift from ad-hoc and short term activities reacting on severe damage by elephants or to retaliatory killings by people to long-term strategies

of coexistence. Clearly, a code of best practice is lacking. Sound monitoring is missing in many cases scientific testing appears inappropriate, e.g. due to absence of control groups having zero interventions, so knowledge is based on experience, which varies strongly from area to area. In case of a malfunction of a measure, most frequently only the fact of malfunctioning, not the reason behind it, is transported. A common fact e.g. is that many technical mitigation strategies require high maintenance (e.g fences, trenches, beehives etc.). In case of low maintenance and therefore failure of a measure, only the information on inefficacy is transported, but not the background to the failure.

Also a more open sharing of accomplishments and challenges of HEC mitigation tools and the circumstances under which they were used, would strongly help HEC managers to design more effective strategies. Launching a platform for exchange on the effectiveness of measures and the circumstances under which they work or not, is regarded as highly useful. The exchange of experts, experiences and knowledge are important to serve a broad view on HEC on a national and international level.

> *"The circumstances under which [HEC mitigation] measures work or not work have to be understood."*
>
> Statement by interviewee 00U

The creation of an environment for people and elephants to coexist is the most promising strategy for the long-term. This implies the definition of farming areas with protected and improved farming strategies such as conservation farming or the use of crops which are unattractive to elephants, as well as protected natural habitat/corridors for elephants. Truly participatory land-use planning recognizes human development and wellbeing. It is based on inclusive collaboration and true and ethical benefit sharing.

A strong need has been observed in designing and implementing effectively working financial measures. As governmental compensation schemes are very likely to fail, combining community-based compensation schemes, e.g. with the condition of using crop protection measures, could motivate farmers in crop protection and at the same time increase financial security. Comprehensive and transparent schemes managed on local level and mainly funded by income generated through the presence of wildlife and coupled to the use of crop protection measures are giving direction for efficient HEC mitigation. Upscaling of the development of livelihoods which are not dependant on subsistence farming of attractive crops is still massively lacking behind. Business-centred approaches for sustainable income generation need to be included into the planning. Such processes, however, need to be professionally facilitated.

HEC management and community development work currently are topics that seem to be plugged to law enforcement projects on elephant conservation. Given the complexity and importance of the topic for long-term perspectives such an approach does not seem suitable. Working towards a long-term coexistence of people and elephants should be taken more seriously in conservation programme development and implementation. Therefore, long-term funding and long-term presence of skilled, professional community workers are required in HEC areas. Community work mainly requires human resources and professional management. As long-term presence and consistency are required for such programmes, funding of professional local NGOs seems to be the way forward.

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