Five strategies to mitigate human-elephant conflict in the Kasigau wildlife corridor of Kenya

Lynn Von Hagen[1], Bruce A Schulte[1], Helena I Kiute[2], Simon Kasaine[3], J Gibran Mwanganda[4], Christopher A Lepczyk[5]*

[1]Western Kentucky University, Department of Biology, Bowling Green, KY 42101, USA
[2]Independent Consultant, Taita Taveta County, Kenya
[3]Wildlife Works, Maungu, Kenya
[4]Ministry of Agriculture, Taita Taveta County, Kenya
[5]Auburn University, College of Forestry, Wildlife and Environment, Auburn University, Auburn, AL 36849, USA

*corresponding author: lvonhagen@comcast.net

Abstract

Human interactions with elephants are increasing throughout the African savannah elephant's range as habitat loss and modification and a growing human population continue to bring people and elephants into contact. These interactions can become negative when elephants are tempted into farmland, consume farmers' crops, or destroy water supplies, leading to human-elephant conflict. Each community coping with regular wildlife conflicts faces unique socio-ecological circumstances and constraints. Therefore, understanding the challenges within each system is a crucial step in designing customized management plans and mitigation interventions, adapted to the situation. We used a combination of survey results and participatory fuzzy-logic cognitive maps from six farming communities in south-east Kenya from previous studies, to understand the complex drivers and consequences of conflicts with elephants and how farmers conceptualize these interactions. These data informed the creation of five main strategies for mitigating the impacts of crop-raiding by elephants: deterrent methods, climate-smart agricultural techniques, alternative livelihoods, safety around elephants, and environmental stewardship. We consulted with local experts to design and deliver workshops in the six communities to present potential solutions within the strategies and to provide the content for a take-home manual. Although no single solution has emerged as the ideal way to mitigate these encounters, the workshops demonstrated a variety of approaches that can alleviate farmers' financial and safety concerns. Future work should include understanding barriers to wider acceptance of such methods and evaluating the efficacy of multifaceted approaches. Creating a customized curriculum for workshops informed by social science data can provide vital information for local people who want to co-exist alongside elephants and other wildlife.

Additional Keywords: community-based conservation, conservation planning, conservation social science, human-wildlife co-existence

Résumé

Les interactions entre l'homme et les éléphants sont en hausse au sein de l'aire de répartition de l'éléphant de savane africain, en raison de la perte ou des modifications de son habitat et d'une population humaine croissante. Ces interactions peuvent s'avérer délétères lorsque les éléphants sont tentés de pénétrer dans les terres agricoles, ravagent les cultures ou détruisent les réserves d'eau. Chacune des communautés devant faire face à des conflits avec la faune sauvage est confrontée à des circonstances et des contraintes

socioécologiques uniques. C'est pourquoi la compréhension des défis propres à chaque contexte est une étape cruciale dans la conception de plans de gestion et d'interventions d'atténuation sur mesure et adaptés à la situation. Nous avons extrait de recherches précédentes des résultats d'enquêtes ainsi que des modèles mentaux établis par des groupes participatifs venus de six communautés d'agriculteurs au sud-est du Kenya, afin d'appréhender les moteurs et les conséquences complexes des conflits avec les éléphants et la façon dont les agriculteurs conceptualisent ces interactions. Grâce à ces données, cinq stratégies principales ont émergé pour modérer les impacts des dégâts occasionnés aux cultures par les éléphants: méthodes de dissuasion, techniques agricoles intelligentes sur le plan climatique, moyens de subsistance alternatifs, règles de sécurité autour des éléphants et gestion de l'environnement. Nous nous sommes entretenus avec des experts locaux afin de concevoir et d'organiser des ateliers au sein des six communautés, dans le but de présenter des solutions potentielles dérivant de ces cinq stratégies et de fournir le contenu d'un manuel à emporter chez soi. Bien qu'aucune réponse ne se soit imposée comme le moyen idéal d'atténuer les tensions, les ateliers ont mis en évidence diverses approches permettant de réduire les inquiétudes des agriculteurs en termes de revenus et de sécurité. De futurs travaux devraient se tenir sur les thèmes suivants : la compréhension des obstacles qui empêchent une plus vaste acceptation de telles méthodes et l'évaluation de l'efficacité d'approches multidimensionnelles. La création d'un programme éducatif sur mesure pour les ateliers, qui repose sur des données de sciences sociales, peut fournir des informations cruciales aux populations locales souhaitant coexister avec les éléphants et autres animaux sauvages.

Mot-clés supplémentaires: Conservation communautaire, planification de la conservation, sciences sociales de la conservation, coexistence homme-faune sauvage

Introduction

Across elephant ranges in Africa, interactions with African savannah elephants (*Loxodonta africana*) are prevalent in farming communities, especially those on the boundaries of protected areas (Wall et al. 2021). The most common form of these interactions occurs when elephants access farms with crops, generally at night, and consume or trample farmers' fields (i.e. crop foraging or crop raiding; Chiyo et al. 2005). Many farmers in these areas are subsistence farmers, consuming or selling what they grow, sometimes living in dire poverty. Therefore, farmers are understandably frustrated at the loss of their crops and may retaliate and attempt to harm elephants, especially if humans have been injured or killed (Nyirenda et al. 2018). These negative interactions, or human-elephant conflicts (HEC), threaten crop farmers' livelihoods and the conservation of Endangered African savannah elephants (Shaffer et al. 2019).

Although multiple solutions have been proposed to mitigate these interactions, no single solution has been found to work in all cases (Blackwell et al. 2016). The efficacy of crop foraging deterrents, such as fencing or traditional methods such as patrolling or burning fire, can vary depending on biotic or abiotic environmental factors, such as wind or rain. Additionally, other socioeconomic barriers remain that limit the use of physical deterrents including the financial cost of deterrents, availability of deterrent materials, community acceptance, and know-how of available effective deterrent types (Snyder and Rentsch 2020; Von Hagen et al. 2024a). This variation can result in the need to use a combination of approaches or mitigation methods customized to the geographical area and the needs of the community to reduce conflict (Shaffer et al. 2019; Sitati and Walpole 2006). Without proper ways to deter elephants from crop foraging, communities can experience multi-dimensional social, cultural and economic impacts. These can include lost opportunity costs, missed work or poor school attendance, food insecurity, and compromised well-being (Barua et al. 2013). Therefore, an important step in planning how to mitigate HEC is understanding the local context and impacts surrounding interactions with wildlife.

To understand how HEC and its impacts vary by community, several social science methodologies are in practice that allows for engagement with community members (with free, prior, informed consent) such as surveys, interviews, focus group sessions, and participatory modelling or mapping (Bennett et

al. 2017). Any planned interventions should be co-designed in conjunction with affected communities, their leaders, and local experts to reflect the complexity often found within these issues (Parsons et al. 2016). One method of customizing information for a geographical area to address HEC is to conduct workshops that bring ecosystem actors together to learn about different techniques that can be incorporated within their households or communities (Treves et al. 2009). However, moving from understanding the specific and complex challenges of HEC in a community to deciding which potential interventions to apply can be challenging, particularly when considering that most types of mitigation solutions need to be affordable, practical, and effective (APE) to be widely adopted and sustainable (Corde 2022). This process involves evaluating data collected from community members and deciding which of the available mitigation measures could be the most valuable to communicate to affected farmers.

In the Kasigau Wildlife Corridor (KWC) in south-east Kenya, elephant interactions are common, and elephant crop-raiding remains a contentious issue between farmers and local wildlife-focused agencies (Kagwa 2011; Von Hagen 2020; Corde 2022). Our previous work in this arid area focused on six farming communities impacted by repeated elephant visits to their crops. Through interviews, surveys, and participatory group sessions, we collected information on the drivers and consequences of these interactions, whether or not crop farmers used techniques to deter elephants, impacts on farmers' livelihoods, and how farmers conceptualized conflicts with elephants. Some of the findings included that farmers lived in fear of elephants, most had not received information on how to build deterrents or live safely with elephants, and crop foraging had a major impact on financial security for farmers (Von Hagen et al. 2023; 2024a; b; Table 1). Using this information, our goals were to create: 1) community workshops to provide information to farmers that would help them mitigate the impacts of elephant crop-raiding in their specific area, increasing co-existence; and 2) a manual to be distributed locally and available electronically for other communities seeking potential solutions.

Methods

The Kasigau Wildlife Corridor lies between the Tsavo East and West National Parks in south-east Kenya in the Greater Tsavo Ecosystem and contains 14 community-owned ranches and one community conservancy. In addition to an increasing human population (some of whom have immigrated from less arid areas), the region is home to the country's largest and growing population of approximately 15,000 African savannah elephants (Waweru et al. 2021), which use the wildlife corridor to transit between the safety of the Parks. A national highway (Nairobi–Mombasa) and the Standard Gauge Railway divide portions of Tsavo East. Rukinga Wildlife Sanctuary (RWS), operated by Wildlife Works, is part of the community ranch complex within the corridor. This area is home to almost 120,000 people, and the preponderance of villages, farms, and nomadic pastoralists create many opportunities for wildlife interactions. The area is mixed-use, containing both businesses and small shareholder farms that typically also keep livestock. Several different types of crops are grown, with maize being the main crop type (much preferred by elephants). Rainfall follows a biannual pattern in this area with long rains typically lasting from March to May and short rains lasting from October to December; the annual average is 1,037 mm. The area is often plagued by drought and soils that have been farmed without replacing nutrients, causing crop losses and exacerbating food insecurity (Kagwa 2011; Von Hagen et al. 2023).

Members from six communities (n = 206) surrounding RWS were the focus of previous studies (Von Hagen et al. 2023; 2024a; b), and the same individuals from the following villages were invited to the workshops: Itinyi and Kombomboro (combined due to the small population size and geographic proximity, hereafter referred to as Itinyi), Bungule, Miasenyi, Kisimenyi, Buguta and Makwasinyi (Fig. 1).

To decide which types of interventions or strategies should be included for discussion in the workshops and the corresponding manual, we examined the data collected from our surveys and participatory sessions in the six respective villages. These sessions included the creation of fuzzy-logic cognitive maps by farmers, revealing several impacts and consequences that were under-represented in other HEC literature. We used generalized linear models to determine if there were demographic categories that identified more common users of deterrents but generally found

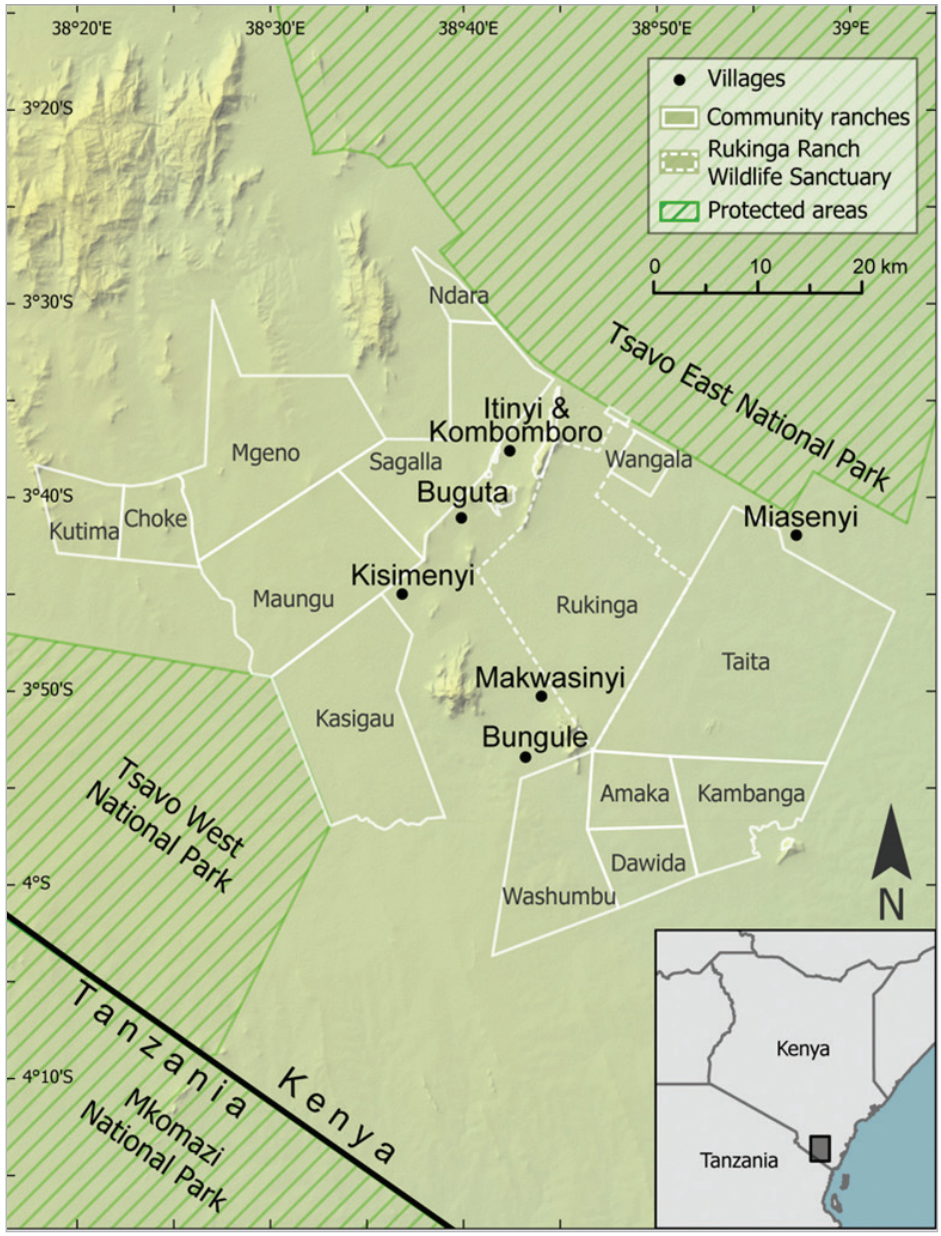

Figure 1. The Kasigau Wildlife Corridor indicating the six villages which participated in the workshops.

homogeneity amongst these results. Therefore, we looked at simple percentages from each survey question to identify where farmers had strong feelings, attitudes, or needs about HEC in their communities (n=206). We considered all results that could logically be addressed by some type of intervention. We then assigned the relevant results of the surveys and group models to five key intervention categories, compiled from the literature and our collective experiences, and these categories helped inform how we developed the curriculum for the workshops (Table 1).

Firstly, we found that very few farmers used effective deterrents (such as beehives, electric, metal strips, or chili fences), and that the vast majority had never received information on such methods (Von Hagen et al. 2024b). Secondly, few farmers had received information on or knew about alternative crops types

or other ways to improve their crop yields, as drought and poor soil quality are major threats to harvests. Thirdly, few farmers had access to information on alternative ways to earn a living other than by farming (Von Hagen et al. 2023). We also found that most farmers lived in some level of fear of elephants and the vast majority had never been given information on ways to act safely around elephants (Von Hagen et al. 2024b). Lastly, in this ecosystem, there are issues with the overexploitation of forest resources such as bushmeat poaching and the unsustainable harvesting of firewood, for illegal charcoal operations. This creates conflict with local agencies and can contribute to greater HEC (Githiru et al. 2017). Environmental interactions also emerged as one of the main themes of the group models (Von Hagen et al. 2024a).

After classifying the data into the five categories (of strategies) that were feasible for this landscape and the affected communities, we contacted local experts in these areas (see Results section). We consulted on the types of methods and discussions to be given at

Table 1. Results of surveys and participatory group mental models conducted in six crop farming villages of the Kasigau Wildlife Corridor of Kenya (n=206), and their corresponding strategy categories

Finding	Strategy Category
54% of farmers used one or more deterrents, 87% of which were traditional methods[1]	Deterrent methods
22% of farmers had received information on how to construct and implement deterrents, and 10% on specific fencing types[1]	Deterrent methods
40% of farmers believed they could invest in deterrents, for the 60% who did not, 100% of them cited economic constraints[1]	Deterrent methods, Alternative livelihoods
84% of farmers had some level of fear of elephants[1]	Safety around elephants
16% of farmers had received information on how to live safely with elephants[1]	Safety around elephants
55% of farmers had no agricultural training outside of schooling or family[2]	Climate-smart agriculture
81% of farmers believe that climate change negatively affected their lives[2]	Climate-smart agriculture
99% of farmers grew maize (corn, a crop favoured by elephants) in addition to other crops[2]	Climate-smart agriculture
82% of farmers showed interest in growing other types of crops	Climate-smart agriculture
39% of farmers had not heard about new agricultural techniques or were unsure[2]	Climate-smart agriculture
66% of farmers had learned of other ways to earn income outside of growing crops[2]	Alternative livelihoods
79% of farmers stated that drought affected their crops every season[2]	Climate-smart agriculture
91% of farmers did not use any type of irrigation[2]	Climate-smart agriculture
Income levels were an important impact of elephant crop raiding by elephants[3]	Alternative livelihoods
Farmers' feelings of security were a major impact when elephant crop-raiding occurred[3]	Safety around elephants
Farmers believed that extensive crop-raids or the presence of elephants caused soil compaction, causing them to have to rent equipment to till soil[3]	Climate-smart agriculture, Alternative livelihoods
Environmental interactions were an important theme that emerged from group mental models with farmers[3]	Environmental stewardship

[1]Von Hagen et al. 2024b
[2]Von Hagen et al. 2023
[3]Von Hagen et al. 2024a

the workshops and which interventions would be included in the take-home manuals. The manual was designed to be visually instructive so that illiteracy or language barriers would not prevent people from learning the techniques. Workshops were planned in conjunction with local leaders and experts, and we used a local facilitator to organize the dates and conduct the workshops, using visual aids such as a projector and fencing components for different presentations. The survey methods described in this manuscript are based on previous studies (Von Hagen et al. 2023; 2024a; 2024b).

Results

Most of the information planned for the workshops were also reflected in the accompanying manual: *Community-Based Mitigation Strategies for African Savannah Elephant Crop Raiding*. The manual was produced in Swahili and English[1]. The first strategy focused on deterrent methods: finding affordable, practical, and effective methods to prevent elephants from entering crop farms. Locally, we had trialled several methods and found that beehive fences and the Kasaine metal strip fence were both helpful (Von Hagen et al. 2021; Corde 2022), (Fig. 2). Demonstrations were arranged and held by specialists from Wildlife Works and Save the Elephants (Elephants and Bees Team), where these two techniques originated. The manual had explicit instructions for the construction and maintenance of these two techniques, as well as more traditional methods such as guarding or patrolling and noise making. We included instructions for making chilli bricks and explained why not to use acacia fences, as our previous study had found them ineffective (Von Hagen et al. 2021). We also provided alternative ideas such as planting chillis as buffer crops or bio fences among other crops recommended that are not favoured by elephants.

The second strategy introduced was climate-smart agricultural (CSA) techniques that could improve crop yields through sustainable farming practices. It should be noted, however, that even though these techniques can improve crop yields to benefit incomes and food security, without implementing deterrent methods or planting crops that are not favoured by elephants, improved crop yields could attract elephants (Weinmann 2018). Since this is a drought-prone area, these techniques were specifically selected to retain and make the most of rainfall when it arrives. The local agronomist from the Ministry of Agriculture of Taita Taveta County shared his expertise at the workshops by demonstrating two techniques that

[1]DOI:10.13140/RG.2.2.28281.34404 (English) and DOI:10.13140/RG.2.2.13181.84965 (Swahili)

Figure 2. Two deterrent methods used in the Tsavo ecosystem that were demonstrated at community workshops (a) the Kasaine metal strip fence, and (b) beehive fences.

originated in Burkina Faso: Zai pits (Fig. 3) and half-moons or U-bands (see manual for full descriptions). Zai pits have been shown to be an effective technique for increasing maize yields in this area (Bowers et al. 2024). As part of the second strategy, we also provided information in the manual on crops that are unpalatable to elephants, how to make organic pesticides (since insect pests in this area are also a source of crop losses), availability of drought-resistant seeds and crop alternatives, such as sorghum and millet which are more resilient to climate change. Additionally, the manual provided information on two methods for establishing kitchen gardens, which are used throughout Africa to create small, elevated gardens for vegetables that can be easily managed in a variety of settings.

The third strategy was alternative livelihoods; sustainable ways to earn money other than farming, so that when elephant crop foraging does occur, farmers have other income sources to help compensate. We introduced the workshop participants to the local basket-weaving cooperative Hadithi, which trains and employs local women to make baskets from sisal and other handicrafts such as beading and sewing. These crafts are sold both locally and internationally, paying a fair market value to local villagers. Another technique featured in the manual is for fodder production. Following harvesting, plant remnants (such as maize stalks) can be left to help fertilize soil or fed directly to livestock. The manual demonstrated how to make simple, affordable fodder bales for later consumption by livestock or to be sold for income-generation. However, not leaving plant remnants (mulch) reduces nutrients returning to the soil, suggesting a need to add fertilizer from livestock manure. Another representative joined the workshops from Zawadisha, a local cooperative, and talked about a micro-loan programme that helps to provide items such as solar lamps, water tanks, and clean cooking stoves, improving living quality. Even if farmers do not use beehive fences to protect their crops, beekeeping can also be profitable for farmers, and apiculture was discussed and included in the manual as an alternative source of income.

The fourth strategy addressed behaviour around elephants so that farmers would feel safer and potentially avoid direct interactions with elephants. A local ranger from Wildlife Works taught key safety behaviours around elephants and how to act when encountering elephants. The same instructions were listed in the manual, as well as information provided on how to secure food and water stores to discourage elephants from accessing these reserves. For example, instead of engaging with elephants by shouting or throwing stones, it was encouraged to back away slowly in the event of an unexpected elephant encounter.

The fifth and final strategy focused on environmental stewardship. The discussions and information in the

Figure 3. An example of Zai pits, a climate-smart agricultural technique used to increase crop productivity.

Figure 4. Five strategies to mitigate African savannah elephant crop raiding, were developed in conjunction with local experts and distributed in manuals to participants from communities in the Kasigau Wildlife Corridor of Kenya.

manual highlighted the importance of elephant presence for a healthy ecosystem (such as providing seed dispersal) and other ways to keep the area productive and beneficial for the community. Ideas presented included using eco-friendly charcoal, ways to sustainably harvest wood, and reducing bushmeat poaching. The five strategies are summarized in Figure 4.

Discussion

The workshops in the local villages were well attended, farmers appeared to be engaged with the materials, and many expressed their appreciation after receiving the training and information. These reactions may be due in part to the fact the curriculum was customized to fit the needs farmers previously identified. Using social science methods is an important component in developing a greater understanding for outside actors or managers about the variation in impact of HEC and other conservation issues for local communities. Incorporating the knowledge of people from local communities affected by HEC is an invaluable component in creating management plans that will benefit their communities (Bennett et al. 2017) and for sustainability. Another factor involved in this process was the use of local facilitators and experts who were trusted community members who advised on the practicality of the methods and were fundamental to connecting with farmers during the workshops. Using local facilitators and experts can help build trust between local people and conservation agencies, which can often be difficult in places where conflict with wildlife or agency personnel has been consistent (Young et al. 2016). Our previous work with these stakeholders and other wildlife agencies within the community also helped establish a level of trust, but in other communities, it may take time,

which can also impact the adoption of methods and the well-being of both people and elephants.

Once information has been distributed to the communities, follow-up surveys are essential to evaluate which aspects of the workshops were successful. Specifically, it is important to determine which participants were able to implement some (or all) methods and why they selected these particular strategies or mitigation methods over others. Likewise, understanding the barriers to implementation or adoption is helpful, including whether these are the same as they were historically. (Furthermore, a new area of potential research is to determine if drought or other environmental factors are more of a threat to harvests than elephants). In our previous interactions, farmers had already identified economic constraints that reduced their wide acceptance of deterrent methods, which is common, especially in communities with limited resources (Shaffer et al. 2019). Another previous finding was that farmers had not received certain information they needed, so understanding communication pathways and effectiveness is also valuable. Critical evaluation of the success in identifying strategies that improve food security and feelings of safety in the short and long term is still needed. This final step is important for revising and improving future workshops so that the mitigation strategy selection process can be iterative, as some techniques may provide initial success but then wane.

Using the process we outline here, conservation managers in other communities can create tailor-made strategies. Given the variability of factors that affect human-wildlife conflict in general, and HEC more specifically, using one approach rarely works for all stakeholders involved in an area. Thus, multi-pronged strategies give farmers options for their lifestyle or financial situation. Financial barriers can be addressed through outside funding or through local microloan programmes (Kaaya and Chapman 2017). Without an integrated approach to mitigation methods, farmers may resort to traditional means where they need to be present, such as patrolling, which may be less effective, time-consuming and more dangerous. Although using all five strategies at once is ideal, it may not be feasible or sustainable for each farming family. Therefore, a stepwise integration of selected strategies can still improve farmers' feelings of security and reduce income losses. Providing multiple strategies as demonstrated in these workshops is necessary to help local communities mitigate elephant crop-raiding and is an important part of incorporating human-elephant co-existence into conservation planning, which can both improve livelihoods for farmers and the conservation of elephants.

Acknowledgements

We would like to thank all our collaborators at Wildlife Works and the amazing community members who welcomed us and who made this work possible. This work was supported by grants from the International Elephant Foundation, the Elephant Manager's Association, and Auburn University, and portions of this project were facilitated in conjunction with the Earthwatch Institute's Elephants and Sustainable Agriculture in Kenya project. A special thanks to Alex Wells for his GIS expertise.

References

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

Bennett NJ, Roth R, Klain SC, Chain K, Christie P, Clark DA, Cullman G, Curran D, Durbin TJ, Epstein G. 2017. Conservation social science: understanding and integrating human dimensions to improve conservation. *Biological Conservation* 205: 93–108. http://dx.doi.org/10.1016/j.biocon.2016.10.006

Blackwell BG, DeVaault TL, Fernández-Juricic E, Gese EM, Gilbert-Norton L, Breck SW. 2015. No single solution: application of behavioural principles in mitigating human-wildlife conflict. *Animal Behaviour* 120: 245–254. http://dx.doi.org/10.1016/j.anbehav.2016.07.013

Bowers MJ, Kasaine S, Schulte, BA. 2024. Zai pits as a climate-smart agricultural technique in Southern Kenya: Maize success is influenced more by manure than depth. Resources 13, 120. https://doi.org/10.3390/resources13090120

Chiyo PI, Cochrane EP, Naughton L, Basuta GI. 2005. Temporal patterns of crop raiding by elephants: a response to changes in forage quality or

crop availability? *African Journal of Ecology* 43: 48–55.

Corde SC. 2022. Alleviating human-elephant conflict through deterrent fences and environmental monitoring in southern Kenya. MSc thesis. Paper 3570.Western Kentucky University, Bowling Green, KY, USA. https://digitalcommons.wku.edu/theses/3570

Githiru M, Mutwiwa U, Kasaine S, Schulte BA. 2017. A spanner in the works: Human–elephant conflict complicates the food–water–energy nexus in drylands of Africa. *Frontiers in Environmental Science* 5: 69. http://doi:10.3389/fenvs.2017.00069

Kaaya E and Chapman M. 2017. Micro-Credit and community wildlife management: Complementary strategies to improve conservation outcomes in Serengeti National Park, Tanzania. *Environmental Management* 60: 464–475. https://doi.org/10.1007/s00267-017-0856-x

Kagwa SK. 2011. Spatial distribution of human elephant conflict (HEC) and characterization of crop-Raiding elephants in Kasigau Region, Kenya. MSc thesis. Paper 1083. Western Kentucky University, Bowling Green, KY, USA. https://digitalcommons.wku.edu/theses/1083

Nyirenda VR, Nkhata BA, Tembo O, Siamundele A. 2018. Elephant crop damage: Subsistence farmers' social vulnerability, livelihood sustainability and elephant conservation. *Sustainability* 10 (10): 3572. https://doi.org/10.3390/su10103572

Parsons M, Fisher K, Nalau J. 2016. Alternative approaches to co-design: insights from indigenous/academic research collaborations. *Current Opinion in Environmental Sustainability* 20: 99–105. https://doi.org/10.1016/j.cosust.2016.07.001

Shaffer LJ, Khadka KK, Van Den Hoek J, Naithani KJ. 2016 Human-elephant conflict: A review of current management strategies and future directions. *Frontiers in Ecology and Evolution* 6 (10). https://doi.org/10.3389/fevo.2018.00235

Sitati NW and Walpole MJ. 2006. Assessing farm-based measures for mitigating human-elephant conflict in Transmara District, Kenya. *Oryx* 40 (3): 279–286.

Snyder KD and Rentsch D. 2020. Rethinking assessment of success of mitigation strategies for elephant-induced crop damage. *Conservation Biology* 202 (34): 829–842.

Treves A, Wallace, RB, White S. 2009. Participatory planning of interventions to mitigate human-wildlife conflicts. *Conservation Biology* 23 (6): 1577–1587.

Von Hagen RL, Kasaine S, Githiru M, Amakobe B, Mutwiwa, UN, Schulte BA. 2021. Metal strip fences for preventing African elephant (*Loxodonta africana*) crop foraging in the Kasigau Wildlife Corridor, Kenya. *African Journal of Ecology* 59: 293–298.

Von Hagen L, Schulte BA, Dunning K, Steury TD, Githiru M, Zohdy S, Lepczyk, CA. 2023. Farmer attitudes on climate change, farming practices, and livelihood threats, and the impact to conservation in the Kasigau Wildlife Corridor, Kenya. *Human Ecology* 51: 685–697.

Von Hagen RL, Gray S, Schulte BA, Githiru M, Kiute H, Lepczyk CA. 2024a. Participatory modeling across Kenyan villages facilitates insight into the complexity of human-elephant interactions. *Oryx*, at press.

Von Hagen RL, Schulte BA, Steury TD, Dunning K, Githiru M, Zohdy, S, Lepczyk, CA. 2024b. Lack of crucial information exacerbates barriers to mitigating human–elephant conflicts in rural Kenya. *Oryx*, http://doi.org/10.1017/S0030605323001795

Wall J, Wittemyer G, Klinkenberg B, LeMay V, Blake S, Strindberg S, Henley M, Vollrath F, Maisels F, Ferwerda J, Douglas-Hamilton I. 2021. Human footprint and protected areas shape elephant range across Africa. *Current Biology* 31: 2437–2445. https://doi.org/10.1016/j.cub.2021.03.042

Weinmann S. 2018. Impacts of elephant crop-raiding on subsistence farmers and approaches to reduce human-elephant farming conflict in Sagalla, Kenya. MSc thesis. University of Montana, Missoula, MT, USA.

Waweru J, Omondi P, Ngene S, Mukeka J, Wanyonyi E, Ngoru B, Mwiu S, Muteti D, Lala F, Kariuki L. 2021. National Wildlife Census 2021 Report. Kenya Wildlife Service, Nairobi.

Young J, Searle K, Butler A, Simmons P, Watt A, Jordan A. 2016. The role of trust in the resolution of conservation conflicts. *Biological Conservation* 195: 196–202. http://dx.doi.org/10.1016/j.biocon.2015.12.030