

**CONTRIBUTED PAPER**

Case study of participatory action research for wildlife conservation

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Abstract

Negative interactions between humans and wildlife create one of the greatest threats to biodiversity conservation. When wild animals damage the crops in agricultural fields, subsistence farmers suffer food insecurity and economic instability. Animals can be killed or injured during these interactions, and communities may develop negative feelings about conservation. To address conservation concerns, projects should look at both sides of these interactions. A Participatory Action Research approach allows researchers and community members to work collaboratively to investigate and take action in response to this issue. Our team developed a community project to determine residents' perceptions of the benefits and costs of living around Kibale National Park, Uganda, and to implement changes to mitigate those costs. During our initial survey in 2015, we found that over 80% of our 114 respondents were subsistence farmers with no other source of income. All respondents felt that crop damage by wild animals was the biggest problem with living near the park, and they had negative feelings about the park and animals. Thus, we worked with project participants to establish the following land-use changes throughout 2016 and 2017: (a) planting garlic as a cash crop, (b) planting tea as a buffer crop, (c) building beehive fences, and (d) maintaining a trench around the boundary of the park. Through monthly surveys, we assessed the success of these changes on reducing crop damage and improving conservation initiatives. Compliance with land-use changes was significantly associated with a reduction in the events of crop damage, which has implications for economic stability and an individual's attitude about conservation. This project provides guidelines for using Participatory Action Research methods to develop sustainable interventions to improve human-wildlife interactions.

KEYWORDS

crop damage, human-wildlife interactions, protected areas, subsistence farming

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1 | INTRODUCTION

In places where humans and wildlife interact, conflicts can arise that result in negative consequences for both human communities and wildlife conservation (Digun-Aweto & Van Der Merwe, 2019; Horgan & Kudavidanage, 2020; Mekonen, 2020; Pooley et al., 2016; Siljander, Kuronen, Johansson, Munyao, & Pellikka, 2020). This dynamic creates one of the greatest threats to biodiversity conservation in and around protected areas. It threatens the survival of endangered species (e.g., Kumar, Gama, Raghunath, Sinha, & Mishra, 2008; Sarasola & Maceda, 2006), results in changes to ecosystems (Estes et al., 2011), and reduces rates of biodiversity (Nyhus, 2016; Redpath et al., 2013). At the same time, it poses serious consequences for human health and wellness, economic security, and safety (Mackenzie & Ahabyona, 2012; Mwangi et al., 2016; Paige et al., 2014). Successful attempts at mitigating these negative interactions should balance the conservation of endangered species with the needs of local communities (Dickman, 2010; Nyhus, 2016; Redpath et al., 2013; Travers et al., 2019; Treves, Wallace, Naughton-Treves, & Morales, 2006).

Wildlife conservation research is often focused on studying the species or habitat of interest rather than human behaviors, yet successful conservation initiatives must address human activities that threaten wildlife (Travers et al., 2019) and the underlying human perceptions of wildlife and potential threats from wildlife that influence human behaviors (Bhatia, Redpath, Suryawanshi, & Mishra, 2019). Conservation researchers have relatively few methods for understanding the cultural and social conditions underlying human-wildlife interactions and the research is often designed to benefit wildlife rather than the human communities (Pooley et al., 2016). There is a need for better methods, more interdisciplinary approaches, and collaborative work toward improving human-wildlife interactions (Pooley et al., 2016). Applying Participatory Action Research methods to address negative interactions between humans and wildlife offers a promising avenue for biodiversity conservation. Participatory Action Research allows researchers and participants to work together to understand and take action to improve a particular situation (Baum, MacDougall, & Smith, 2006). A common approach in the field of global health (Baum et al., 2006), researchers are now expanding its use into agroecology, sustainable development, and beyond (Eelderink, Vervoort, & van Laerhoven, 2020; Keahey, 2020; Méndez, Caswell, Gliessman, & Cohen, 2017). Taking a community-based approach to Participatory Action Research allows researchers to incorporate

valuable expertise from the community, allows community members to be equitably involved with every level of planning and action, and creates a sustainable plan for action (Dodsworth, 2019; Ferré, Jones, Norris, & Rowley, 2010; Keahey, 2020). The research results ultimately trigger the planned community action (Eelderink et al., 2020). For all of these reasons, Participatory Action Research offers a promising avenue for investigating human perceptions of wildlife and potential interventions to mitigate negative interactions.

Crop damage is one of the main sources of negative interactions between humans and wildlife in areas where farming communities live in close proximity to protected areas (Digun-Aweto & Van Der Merwe, 2019; Horgan & Kudavidanage, 2020; Mekonen, 2020; Siljander et al., 2020; Webber & Hill, 2014). This issue becomes especially problematic when animals are able to destroy the only source of food for subsistence farmers. In these cases, crop damage may lead to food insecurity, which has far-reaching effects on communities. Family members must be available to guard the crops at all times, which means that they are not able to pursue other jobs and children miss school and may drop out (Mackenzie, 2012). Close interactions with wildlife and the presence of these animals in gardens can increase zoonotic disease transmission (Paige et al., 2014). Thus, crop damage poses a tangible threat to the health and wellness of people living near protected areas. As a result, people work to protect themselves and their families from these threats, including through injuring or killing wild animals in their gardens (Goldberg, Paige, & Chapman, 2012; Wilson, Hauser, & Wrangham, 2007). This dynamic is often referred to as human-wildlife conflict (e.g., Digun-Aweto & Van Der Merwe; Horgan & Kudavidanage, 2020; Siljander et al., 2020) because both parties experience negative effects (Madden, 2004), but there are critiques of using this term (e.g., Bhatia et al., 2019).

Many of the animals that cause the most crop damage are also endangered, such as elephants (*Loxodonta africana*) and various species of nonhuman primates (e.g., chimpanzees, *Pan troglodytes*; red colobus monkeys, *Piliocolobus tephrosceles*; and L'hoest monkeys, *Cercopithecus lhoesti*). Elephants are known to cause significant damage to private property across their range (Hoare, 2012). Similarly, a variety of endangered nonhuman primates are well-known crop damagers, including chimpanzees, gorillas, orangutans, macaques, and red colobus monkeys (Estrada et al., 2017; Linkie, Dinata, Nofrianto, & Leader-Williams, 2007).

Kibale National Park (KNP) in western Uganda is a protected area that is largely surrounded by subsistence farming populations. Because of that, people's livelihoods

are threatened by crop damage from animals living in the park, including a variety of nonhuman primates and elephants (Naughton-Treves, 1997, 1998, 1999). Elephants destroy large areas of farmland both by feeding on and trampling plants (Naughton-Treves, 1997, 1998, 1999). Several primate species, including red colobus monkeys, redbelt monkeys, baboons, and chimpanzees, are also known to damage crops (Naughton-Treves, 1997). Although people living in these communities do not consume primate meat, they will kill nonhuman primates, including chimpanzees, when such animals encroach on gardens (Goldberg et al., 2012; Wilson et al., 2007).

KNP is a well-known site for long-term scientific research as well as community outreach projects (Wrangham & Ross, 2008). Uganda has a long history of community engagement around protected areas, but much of the focus of that engagement has been on education and outreach, not mitigation (Travers et al., 2019). Additionally, engagement does not receive the same level of investment as law enforcement around protected areas (Travers et al., 2019). This approach may not be sufficient to effect long-term changes to both attitudes and behaviors associated with wildlife conservation (Travers et al., 2019). Despite efforts both within and outside the park to promote conservation and protect the endangered species living in the park, tensions still exist between researchers and conservation area managers and the local communities. For example, providing jobs to local assistants has become an employment opportunity associated with research in KNP, but there are limited job opportunities, which can cause jealousy within the community (Mackenzie & Ahabyona, 2012). Additionally, despite ongoing snare removal programs within the park, chimpanzees continue to suffer from new snare wounds each year (Wrangham & Mugume, 2000). The pattern of crop damage around KNP negatively affects both the local communities who rely on the crops and the wildlife that are killed or injured by the people protecting their food sources, which is consistent with the detrimental consequences for people and wildlife that can be associated with human-wildlife interactions (Madden, 2004).

To assess the issues and concerns about human-wildlife interactions around KNP, we conducted a multi-phase Participatory Action Research project to: (a) determine what residents perceived to be benefits and costs of living near the park and determine potential intervention strategies for items identified as the greatest costs, (b) implement land-use changes to reduce human-wildlife interactions, and (c) monitor the perceived effectiveness of these changes on reducing crop damage. Here we provide the results of this project to date and discuss the ongoing work. Importantly, we present methods for successfully implementing these or similar interventions

in other areas where crop damage by wildlife is an issue and provide evidence of their effectiveness. We believe this paper details a major advancement in mitigating one of the main threats to biodiversity conservation and offers promising avenues for future work.

2 | METHODS

2.1 | Site

This study was conducted in local communities around KNP. KNP is a mid-altitude, evergreen rainforest that is 795 km² in western Uganda (0°13'–0°41'N, 30°19'–30°32'E). KNP is managed by the Uganda Wildlife Authority (UWA), which oversees all the national parks in Uganda. KNP is home to elephants, antelopes, cats, 13 species of primates, and a large variety of birds and insects, among other things. Many of the species that are known to damage crops in KNP are threatened or endangered animals, including elephants (*Loxodonta africana*), chimpanzees (*Pan troglodytes*), grey-cheeked mangabeys (*Lophocebus albigena*), red colobus monkeys (*Piliocolobus tephrosceles*), and L'hoest monkeys (*Cercopithecus l'hoesti*).

This study was conducted in four communities bordering the park (Figure 1). These four communities were not contiguous but were paired such that we had two sets of neighboring communities. The two pairs were located at a distance from each other along the boundary of the park, and there was no reason to believe that individuals from one community pair interacted much, if at all, with individuals from the other community pair. However, we do know that participants within either pair of neighboring communities did interact with each other and were aware of the project activities in their neighboring community. Participants were community members who had land that directly bordered the park. Previous research (Mackenzie, 2012) and our initial surveys suggested that these households were the most in need of intervention and the most likely to invest time in activities to reduce crop damage.

2.2 | Participatory action research

We worked closely with local community members (the project participants) to design and implement the project. Collaborations between communities and researchers help to improve the application of results after a study (Wadsworth, 2006) or in this case, as part of the study. Participatory Action Research may be particularly important for conservation efforts where outside research on

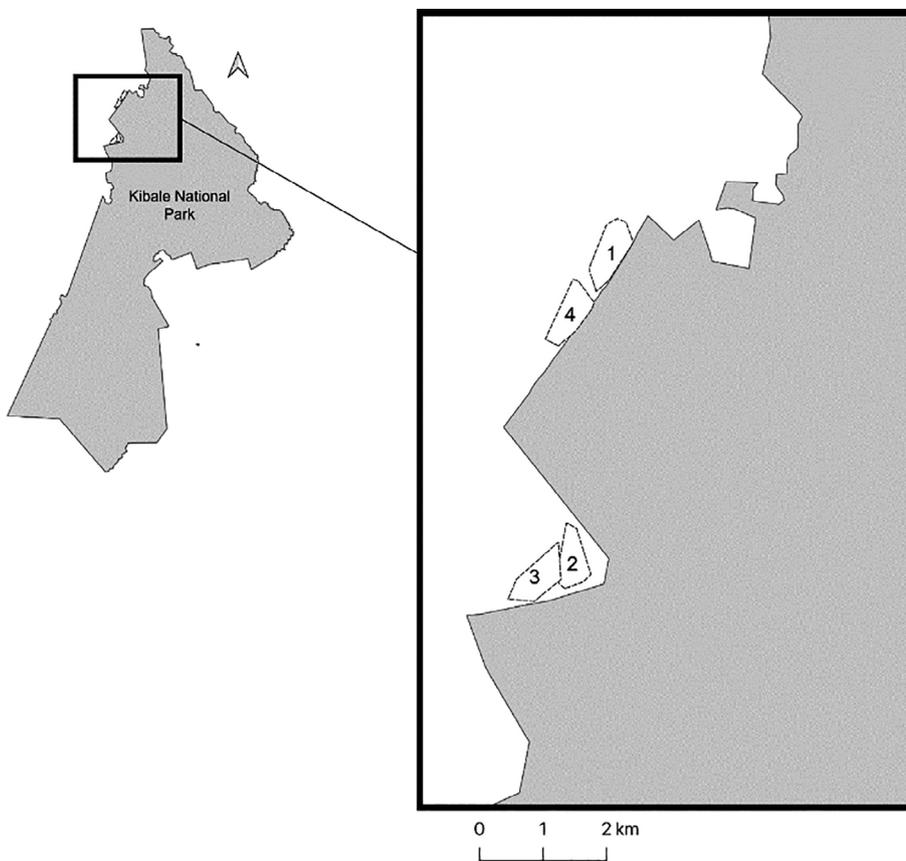


FIGURE 1 In this map of Kibale National Park, the participating communities are indicated by their number

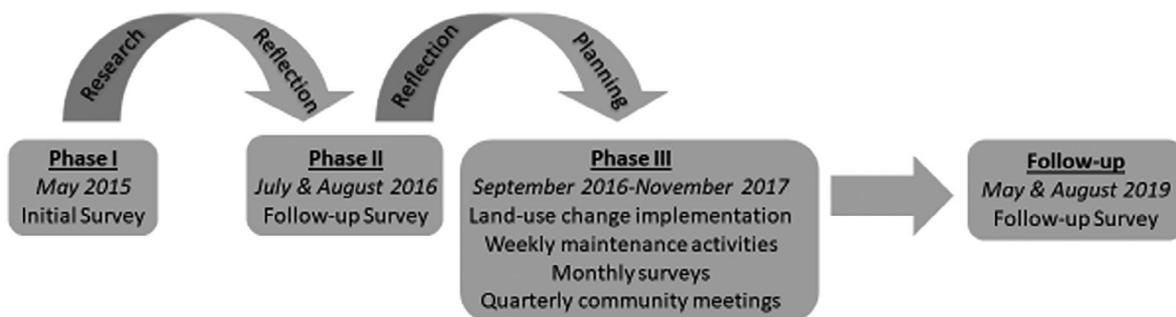


FIGURE 2 This diagram shows the different phases of the project, including dates and major project activities

environmental issues and enforcing conservation strategies on local communities can often cause animosity and reduced success of these efforts. Using Participatory Action Research methods allowed us to evaluate the capacity for local community commitment to changes in land-use practices and to ensure that community members were invested in the conservation of their natural resources (Campbell & Vainio-Mattila, 2003). Furthermore, it allowed us to incorporate much-needed local knowledge of ecosystems into the research (Moller et al., 2009). Similar to the approach used by Méndez et al. (2017), our project incorporated cycles of research, reflection, and action (Figure 2).

2.3 | Phase I

The first phase of this project was to determine the concerns of people living near the park. This phase of the project was completed by the core research team alone; UWA was not involved with Phases I and II of the project. The participating households were identified by walking along the boundary of the park in four communities and recruiting someone from every household associated with land that shared a boundary with the park. One member of each household was asked to participate in a short, orally administered survey that took ~20 min to complete (Appendix A). All surveys were conducted in

the local language by one of the project team members between 1100 and 1800 hr Monday through Saturday during May 2015. We found that these hours were more convenient for the participants because it was after they had completed their work in the garden for the day.

The survey included questions about the respondent's demographics, land, attitude towards the park and perceived attitudes of fellow community members toward the park, perceived benefits and costs associated with living near the park, ideas for what would improve their attitude toward the park, experience with crop loss caused by animals from the park, and interest in becoming involved in a project to prevent crop loss.

After all data were collected and tallied, the most common responses for potential land-use change strategies for each community were listed in order of their popularity (see Results). Based on the findings in published literature and consultation with local organizations (e.g., a local business promoting garlic farming), a short list of potential interventions was created for each community (planting garlic as a cash crop, digging and maintaining a trench, constructing beehive fences, and growing tea as a buffer crop). These lists were personalized for each community from the most popular responses to our survey and informed by previous research on logistical constraints or issues with effectiveness.

2.4 | Phase II

A new survey was created for each community to ask each participating household about their interest in implementing the intervention strategies that were identified for that community and to get a baseline for the amount of crop raiding¹ that had occurred in the previous month (Appendix B). The survey was similar to the survey used in Phase I, but also specifically asked if the respondent would be willing to try each of the methods identified for their community and how much space on their land they could dedicate to each strategy. All surveys were orally administered by a team member in the local language in the afternoon and evening hours during July and August 2016.

2.5 | Phase III

Land-use changes were implemented in each community on a rolling basis. For each strategy, we consulted with local businesses and farmers with experience implementing the given strategy and allowed participants to prepare their land a few months in advance of each strategy being implemented. One kilogram of

garlic was given to each participating household in October 2016, and our team, as well as members of a local garlic business, were available to help with planting and providing feedback about the growing.

Starting in January 2017, weekly trench maintenance activities were organized by community members for a set date and time each week and were attended by members of our team and an UWA ranger. Existing lengths of trench that had been previously dug by UWA or the communities were maintained, and additional lengths of trench were dug by the participants. The trench is a long, deep ditch dug to specifications that make it difficult for elephants and some other animals to cross (a minimum of 7-ft deep by 6-ft wide). Community members can only access park land with UWA's permission, and because the trench spans the park and private land, a ranger was present for these weekly activities. Our project provided trench maintenance supplies, but the participants did the work to maintain the trench.

In early 2017, the two communities that had requested beehive fences constructed them by hanging beehives from wire across swampy areas where the trench could not be dug. The hives had been supplied by our project several months before and were naturally colonized by local bees. Additional beehives were distributed in the months and years following as funds became available and were also provided to the third community that requested them. In communities with beehive fences, trench maintenance times were also used to work at the apiaries (which were also located on park land) with the oversight of the UWA ranger. Our project provided the necessary beekeeping supplies and equipment for collecting honey, which was then available for the participants to use or sell. In September 2017, tea seedlings were distributed in the one community interested in growing tea.

We had quarterly meetings with the community groups and UWA representatives (in addition to weekly maintenance activities). We conducted monthly surveys in each community before, during, and after the implementation of land-use changes. Participants were asked the same questions from Phase II about perceived crop damage in the past month (species, crop loss, etc.), as well as questions about involvement with intervention strategies. These results are based on self-reports and participants' perceptions of crop raiding events. These methods were used due to logistical limitations that impaired our ability to collect quantitative data on crop damage each month, primarily related to the need to use funds for the implementation of the land-use changes rather than for personnel and equipment to survey gardens each month. Perceptions, however, are also important in shaping attitudes toward conservation initiatives (Digun-Aweto & Van Der Merwe, 2019; Webber & Hill, 2014).

In 2019, we conducted follow-up oral surveys to the original 2015 and 2016 surveys in the original three communities that were still actively participating in the project. We conducted these surveys at the same time of year that they were done in 2015 and 2016 and asked the same questions that were originally asked, including the respondent's attitude about the park, what they thought the community attitude was towards the park, and how much crop raiding they had experienced in the previous season. These data were used to compare pre-and post-project attitudes towards KNP and perceived rates of crop raiding.

2.6 | Data analysis

Data were tested for normality and found to not be normally distributed; thus, a Kruskal-Wallis test was used to determine variation in participation in land-use change activities between communities. To determine perceptions of rates of crop raiding before and after the land-use changes, a Pearson's Chi-squared test was used to compare reports of crop raiding in the previous season. Fisher's Exact Test scores were used to determine any changes in the perception of KNP before (2015 and 2016) and after (2019) participation in the project for compliant communities. Finally, generalized linear models were created for Communities 2, 3, and 4 to determine any significant relationship between the number of reports of crop raiding events over the year of monthly data collection. All data were analyzed in R version 4.0.0 (R Core Team 2020).

3 | RESULTS

3.1 | Phase I

We surveyed a total of 114 people. Our respondents ranged in age from 18 to 90 years old, with an average age of 44. Fifty-three percent were women and 47% were men. Farming was the occupation of 81% of respondents. Only 19% of respondents had other means of income. Seventy percent of respondents said that the community had a negative view of KNP. Ninety-eight percent of

respondents owned at least one piece of land. Of these, 10% also had rented land and discussed crop raiding issues on that land with us in the same survey form. The average size of land was 2.4 acres (range = 15–0.25 acres). Sizes of land differed between communities (Table 1). In the community with the largest average land size, only one household had less than an acre of land. In the other three communities, approximately one-third of participants had less than an acre of land.

Of the 114 respondents, all but two said they had experienced crop raiding on their land. One of these two did not grow any food crops on his land and indicated that as a reason he did not experience crop raiding. However, he identified crop raiding as a serious problem in the community and was interested in participating in a project to reduce crop losses. The other respondent who did not experience crop damage by wildlife did not have land that bordered the park, and he said that animals did not cross the road to reach his land. Of the 112 respondents that experienced crop raiding, 109 experienced crop losses from elephants and 107 from baboons, and 50 respondents indicated crop losses from other non-human primates, including 31 respondents who lost crops to chimpanzees. Of these 112 respondents, 97 had experienced crop damage by wildlife in the last harvest season prior to the survey. Two of these respondents who had previously experienced crop damage by wild animals that did not in the previous harvest season said that they had not planted food crops and specified that as a reason that they did not have damage. The other 13 respondents did not specify a reason for not having damage in the past season despite generally reporting crop raiding. Of the 97 who had experienced crop damage in the previous harvest season, 93 reported damage from elephants, 87 reported damage from baboons, and 33 reported damage from other nonhuman primates.

In an open-ended format, we asked, "What activities would you be willing to try on your land to reduce crop raiding?" People had a wide range of suggestions, including beekeeping, planting coffee, tea, or eucalyptus, animal keeping (cattle, goats, poultry, and pigs), brick making, using chili pepper as a deterrent for animals, digging a trench, installing an electric fence around the park, putting in an UWA outpost at the edge of the park, growing unpalatable crops (such as garlic, onions, or red

TABLE 1 Reported land sizes in each community

	Community 1	Community 2	Community 3	Community 4
Average land size	3.5	1.6	2.5	1.8
Median land size	3	1	1.5	1.25
Number of households	28	37	24	25

TABLE 2 Survey results of interests in different strategies

		Community 1	Community 2	Community 3	Community 4
2015 interests	Garlic	69%	64%	60%	76%
	Bee fences	54%	33%	44%	40%
	Tea	23%	28%	28%	32%
	Coffee	42%	35%	54%	42%
	Trees	31%	35%	50%	27%
2016 interests	Garlic	96%	88%	94%	96%
	Bee fences	91%	NA	58%	NA
	Tea	42%	NA	NA	24%
	Trench	75%	65%	69%	72%

Note: Highlighted boxes indicate that the strategy was selected and implemented for that community.

pepper), having someone guard the animals that damage crops, hiring someone to guard the gardens, accepting resources (if provided) to cover all of their household needs (such as money to buy food), and training people in the community to deal with the animals. When asked specifically about growing coffee, garlic, tea, or trees or keeping bees, the most popular intervention was garlic (Table 2). Additionally, 87 respondents indicated that there was already a trench between their land and the park.

3.2 | Phase II

There was variation in interest for trying different strategies between community members when asked specifically about participating in the strategies that had been popular in their communities during Phase I. All four communities were interested in trying garlic and trench maintenance as a strategy, but only two were interested in beehive fences and one of those in tea as a buffer crop (Table 2). That meant that two communities were interested in planting garlic and maintaining the trench, one community was interested in planting garlic, maintaining the trench, and constructing beehive fences, and one community was interested in all four strategies together. Similar to in *Phase I*, 75% of respondents said the community had a negative view of KNP, which was not significantly different from the previous year, according to the Fisher Exact Test score ($p = .079$).

3.3 | Phase III

Between 3 and 4 km of trench were maintained in each community, and a total of 275 beehives were used to establish beehive fences that were placed intermittently

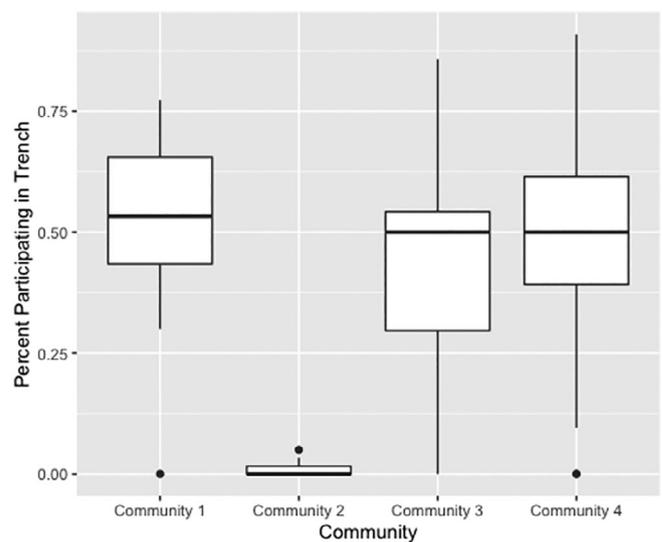


FIGURE 3 The percentage of survey respondents participating in trench maintenance each month was calculated for each community. Community 2 had significantly lowered participation in trench maintenance than the other three communities

along the boundary in swampy areas where the trench could not be dug. In total, these beehive fences covered ~1.5 km along the boundary in three communities. Garlic was harvested ~6 months after the first planting and garlic growing continued with seasons every 6 months after this start date. Project participants were free to sell or use their garlic as they preferred, but we also offered a guaranteed market to buy back any garlic they grew, if they chose to do so. Unfortunately, due to drought and unpredictable rain patterns, the tea did not survive.

Compared to the other three communities, significantly fewer people in Community 2 participated in trench maintenance ($H[3] = 26.298$, $p < .001$; Figure 3). Participants in Community 1, Community 3, and Community 4 reported decreasing incidence of crop raiding

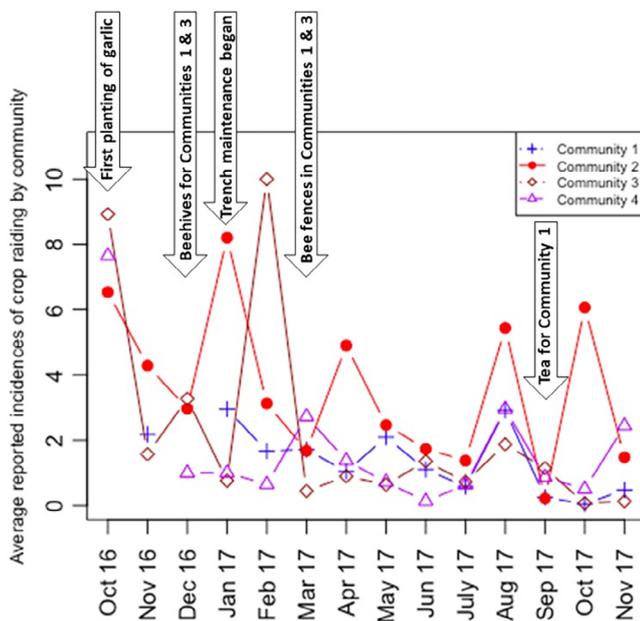


FIGURE 4 The average number of crop-raiding events reported per month for each community varied over time, as is expected with natural variation in crops available and thus crop raiding. Despite this variation, the three communities that actively participated in trench maintenance (Communities 1, 3, and 4) showed a consistently lower rate of crop raiding in the second half of the study compared with the first half and communities that also had beehive fences at the time these data were collected (Communities 1 and 3) reported even lower rates of crop raiding than the other two communities in the second half of the study

over time as these intervention strategies were being implemented, and in particular, the two communities with beehive fences (1 and 3) reported lower rates of crop raiding after the implementation of this strategy (Figure 4). However, Community 2 did not experience a sustained reduction in crop raiding (Figure 4). There is seasonal variation in crop raiding due to agricultural cycles. This seasonal variation is reflected in the reported rates of crop raiding by participants; thus, a decrease in reported crop raiding events from 1 month to another should not be used as an indicator of a successful mitigation strategy. Instead, we used a sustained reduction over time as a measure of success, and we compared reports of crop raiding events for the same time period in different years. Of the three communities that were surveyed in October 2016, two of them reported fewer crop raiding events a year later in October 2017. Generalized linear models of the perceived number of crop raiding events in Communities 2, 3, and 4 revealed a significant decrease in Communities 3 (slope = -4.8473 , $p < .001$) and 4 (slope = -2.7438 , $p < .001$) from 2016 to 2017, but not in Community 2, in which there was no significant relationship between the year and the number of reports of crop

raiding ($p > .05$) (Table 3). When we compared the responses from the initial surveys we conducted in 2015 and 2016 and surveys conducted in 2019, we found a significant change in perceived rates of crop raiding in the previous season for the three communities that maintained their trench (2015 to 2019: $X^2(1, N = 178) = 28.26$, $p < .001$; 2016 to 2019: $X^2(1, N = 126) = 13.94$, $p < .001$) with participants being 6.39 more likely to report crop raiding in 2015 and 4.62 more likely in 2016 than in the same season in 2019. In 2019, fewer than 6% of respondents reported that the community had negative feelings about KNP, which was significantly fewer than in 2015 ($p < .001$) or 2016 ($p < .001$, Fisher Exact Test).

4 | DISCUSSION

Negative interactions between humans and wildlife have far-reaching effects on biodiversity and human populations alike. Finding sustainable strategies to reduce these negative interactions is imperative to human health and wellness, wildlife conservation, and climate change. Here we provide evidence of the effectiveness of a Participatory Action Research project for reducing negative interactions around a forested national park in East Africa. We outlined the process for collaborating with local communities to select and implement land-use changes with the hope that similar projects can be organized in other areas where subsistence farmland and forest animals exist in close proximity. Our data illustrate a reduction in perceived rates of crop raiding and improved attitudes about KNP, suggesting that Participatory Action Research was a successful research approach that balanced the conservation of endangered species with the needs of local communities.

The human population density around KNP is high (Hartter et al., 2015; Mackenzie & Hartter, 2013), emphasizing the importance of finding strategies for humans and wildlife to coexist. Our study participants were primarily subsistence farmers, which is consistent with previous research findings that the majority of people living along the border of KNP are subsistence farmers (Hartter et al., 2015; Hartter & Southworth, 2009). The close proximity of subsistence farmers to crop-damaging species is dangerous for humans and nonhuman animals alike. The findings presented here offer some initial evidence of successful mitigations of this issue, and the long-term impacts should continue to be studied.

Similar to other studies (Digun-Aweto & Van Der Merwe, 2019; Horgan & Kudavidanage, 2020), crop loss due to wild animals in the garden was the primary concern of project participants. Issues with elephants and

TABLE 3 Generalized linear model of the perceived number of crop raiding events in 2016 versus 2017

	Slope estimate	SE	z value	Pr(> z)
Community 2	-0.075	0.151	-0.496	0.615
Community 3	-4.847	0.710	-6.830	<0.001
Community 4	-2.744	0.311	-8.821	<0.001

nonhuman primates were the most common complaints, as has been documented at other sites (Horgan & Kudavidanage, 2020; Siljander et al., 2020), and as previously reported at other sites, those living closest to the protected area suffered the greatest losses (Siljander et al., 2020). Our results find further support for previous research on the effectiveness of trenches and beehive fences to prevent crop damage. Unfortunately, we were unable to evaluate the effectiveness of tea as a buffer crop, but previous studies have found that tea is an unpalatable crop to wild animals that can create a barrier, particularly for nonhuman primates (Hockings & Humle, 2009; Kagoro, 2015). Tea and other crops that are unattractive to elephants and nonhuman primates, such as garlic, can be used to generate revenue for farmers (Gross, McRobb, & Gross, 2016; Kagoro, 2015; Mullan, Goldman, & Sterns, 2008), as seen with our results for garlic in this study.

Participants reported lower rates of crop raiding after beehive fences were constructed over swampy areas, consistent with previous findings (Ngama, Korte, Bindelle, Vermeulen, and Poulsen, 2016; King, Douglas-Hamilton, and Vollrath, 2007; King, Lawrence, Douglas-Hamilton, and Vollrath 2009; King, Soltis, Douglas-Hamilton, Savage, and Vollrath, 2010; King, Douglas-Hamilton, and Fritz Vollrath, 2011). As with the findings of Mackenzie and Ahabyona (2012), our study found a correlation between trenches that were dug to the proper dimensions and maintained weekly and perceived reductions in the amount that animals were crop raiding, suggesting that trenches were effective barriers in areas that were not swampy. Weekly trench maintenance was the key to the effectiveness of these trenches and required community members to participate in these weekly activities. Providing garlic as a cash crop may have been an incentive for community members to initially invest in maintaining the trench as part of a multi-tiered approach; however, the benefits of reduced crop damage from maintaining the trench became an incentive in itself. These results are counter to previous research that suggests that maintenance breakdown can occur when community members feel the benefit of intervention strategies and no longer have the motivation to continue their maintenance (Gross, 2019).

Gross (2019) noted the need to find intervention strategies that maintained motivation and suggested that having a personal connection, regular communication, and a monitoring system may be important for achieving the goal of maintaining motivation. These characteristics are all part of Participatory Action Research and may point to why there was continued maintenance of the land-use strategies in our project. The weekly trench and apiary maintenance programs, which were implemented by the community members as part of the Participatory Action Research approach and were always attended by a member of our team and an UWA ranger, provided the opportunity for regular communication, a personal connection, and a chance to monitor the situation. Additionally, it is possible that our participants continued to have high motivation because they lived on the boundary of the park and could see the animals that were attempting to cross out of the park. Community members commented on moments when they saw elephants and other animals approach the edge of the trench and look for ways to cross. These events may have provided motivation for the participants.

Participants were key decision makers, and all participation was entirely voluntary. The researchers did not benefit from any of the agricultural practices, and all products were the property of the community members. These methods are part of the Participatory Action Research approach and are important for sustainable and equitable conservation work (Dodsworth, 2019; Ferré et al., 2010; Keahey, 2020). In this way, the project differs from some other land-use change projects that require and coerce the cultivation of certain crops as part of a larger agro-business operation (e.g., Mc Guinness, 2016).

In addition to implementing strategies to reduce crop damage, our project facilitated open communication between local community members and UWA, which oversees the management of the national parks and endangered species conservation. Previous studies have shown that conservation conflicts can arise as a result of lack of communication between park managers and local communities (Digun-Aweto & Van Der Merwe, 2019). Part of the goal of UWA is to highlight the benefits people receive from living near a protected area; however, crop damage by wildlife leads to a decrease in the number of community members who feel they benefit from

living near a national park (MacKenzie et al., 2017). One benefit that people may receive from living near the national park is revenue sharing from entrance fees that visitors pay to the park. All communities living around the park qualify to participate in the revenue sharing program, but some communities do not receive benefits from this program because they do not have an organized community group and/or are not in communication with UWA. Through community meetings, weekly trench maintenance, and other interactions, the project created an open dialogue between UWA and the participating communities, helping these communities to be in better communication with UWA about the revenue sharing program. The participating communities eventually also received support from UWA in the form of additional beehives and other materials to help continue to grow the land-use changes along the boundary of the park after they were established.

UWA is also responsible for overseeing the sustainable gathering of resources from the national parks, including firewood and medicinal plants, among other things (Naughton-Treves, Alix-Garcia, & Chapman, 2011). Having more frequent interactions with UWA officials increased the opportunities for community members to request the supervised gathering of these materials. Thus, the participating community members had additional benefits beyond the reduction in crop damage recorded in this study.

Previous studies have shown that people living closest to the boundary of the park incur the highest cost and therefore suggest that UWA should focus efforts in those areas (Mackenzie, 2012). This pattern is also seen around other protected areas (Siljander et al., 2020). We focused our efforts along the boundary of the park and found a benefit to that strategy. In the three compliant communities (Communities 1, 3, and 4), participants reported less crop raiding over time as the land-use changes were implemented. The fourth community (Community 2) had low rates of participation and did not report a sustained decrease in crop raiding events. Although there was significant seasonal variation in crop raiding, over time, the compliant communities reported a decrease in the average amount of crop raiding per month with the two communities with beehive fences having had the lowest rates of crop raiding 1 year after the land-use changes began. In Community 2, the average crop raiding events reported also varied across different seasons but continued to peak higher than the other communities at the end of the year of data collection. The perceived rates of crop raiding in Community 2 were similar in October 2016 and October 2017 (the first month of the monthly surveys and 1 year later). Future studies could investigate what makes some communities

compliant and others not. Regardless of the reasons for compliance, this project was committed to the Participatory Action Research approach, and therefore did not intervene on each participant's decision whether to be active in the project. We believe that allowing the participants to make their own decisions about what strategies to try and how to implement and maintain them was the key to the success of this project, as suggested by previous research on Participatory Action Research (Campbell & Vainio-Mattila, 2003; Keahey, 2020; Méndez et al., 2017; Wadsworth, 2006).

Our study was based on participant perceptions and did not include any direct measures of crop raiding activity. Perceptions can be important for conservation efforts because they can impact attitudes, as we saw in this research and has been documented in other studies (Digun-Aweto & Van Der Merwe, 2019; Webber & Hill, 2014). Future studies should also verify the perceived reduction in crop damage by measuring wildlife activity in participating communities. Long-term studies of animal activity along the border (Naughton-Treves, 1997, 1998, 1999) can help to verify these changes.

Additional benefits that stem from these land-use changes should also be examined in future research, including economic stability, the impact on human health and wellness, and any changes in attitudes toward conservation efforts. Previous work in the communities surrounding KNP had found a relationship between perceived rates of crop raiding and human–environment interactions, including rates of fragmentation (Ryan et al., 2015). In other parts of Uganda, community members who reported human–wildlife conflict were found to be more likely to hunt illegally (Travers et al., 2019). Increasing rates of forest fragmentation and illegal activity in forest habitats have implications for rates of climate change, which makes addressing the concerns of community members living around protected forests important for overall environmental and conservation initiatives.

Travers et al. (2019) found that outreach and educational activities were not sufficient to cause meaningful behavioral change in relation to wildlife crimes, but that people who suffered from human–wildlife conflict were more likely than others to change their behaviors when effective mitigation strategies were implemented. Effective conservation strategies should take a community-based approach, incorporate Participatory Action Research methods, and address the development needs of the local community (Digun-Aweto & Van Der Merwe, 2019). In taking a community-based participatory approach, researchers must be willing to convey and acknowledge the negative feelings of local community members. In the literature, there has been shift away from terms like “crop raiding” (e.g., Horgan &

Kudavidanage, 2020) and “human-wildlife conflict” (e.g., Bhatia et al., 2019) towards using more neutral terms, and while it is important to continue critiquing our use of these terms and moving towards more appropriate terminology, we should not do so if it does not accurately convey the meaning of the words used by our respondents. Communities that do not solely rely on agriculture that is susceptible to being damaged by wildlife are more tolerant of human-wildlife interactions (Digun-Aweto & Van Der Merwe, 2019). Successful efforts at implementing alternative livelihood projects must incorporate investment in local institutions (Travers et al., 2019). Human populations have little incentive to preserve forest patches that harbor animals that threaten their livelihood, making negative interactions between humans and wildlife particularly concerning for larger issues of environmental destruction and the resulting effects of climate change.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

Krista M. Milich, Richard Busobozi, and Moses Kugonza designed the study. Richard Busobozi and Moses Kugonza collected data and oversaw additional data collection. Kayce Sorbello organized and analyzed data. Lev Kolinski carried out additional data analyses. Krista M. Milich led the manuscript preparation, to which all authors contributed and approved final submission.

ETHICS STATEMENT

This research was conducted with the permission of the Uganda Wildlife Authority (Ref: COD/96/02) and the Uganda National Council for Science and Technology

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ENDNOTE

¹ As a Participatory Action Research Project, local community members informed the language used on each of our surveys. Our initial survey started with open-ended questions about benefits and costs of living near KNP in which all respondents described issues with wild animals in gardens, commonly using the Rutooro words “kwoona” or “kwoonerwa.” These terms were translated by English-speaking community members as meaning “raid” or “raiding” and were used in phrases that were defined as “animals getting into the garden and eating/spoiling crops or causing major destruction to the garden.” Although there is debate about the term “crop raiding” in the literature, we are using it here to reflect the words used by our respondents.

DATA AVAILABILITY STATEMENT

Data available upon request.

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APPENDIX A.: PHASE I SURVEY

Name of interviewer: _____ Date of interview: _____.

Respondent Age: _____ Sex: _____ Occupation: _____ GPS: _____.

Location: (circle one) Isule, Nyabinyungu, Kanyansohera, Kyamaguara

- Does your land share boundaries with the park? Yes/No
- What is the distance (in meters) from park boundary to the garden? _____m
- How big is your land? _____ Do you rent or own it? _____
- What is your current attitude about Kibale National Park? (Neg, Pos, Neutral, other?)
- What do you think is the attitude of the community toward KNP? (Neg, Pos...)
- Could you please tell us what are some of the benefits this household receives from living close to the Park? Please rank based on how important they are for this household (“based on their magnitude”)

Benefits of living next to Kibale National Park	Rank

- Could you please tell us what are some of the negative effects this household receives from living close to the park? Please rank based on their magnitude for this household.

Negative effects of living next to Kibale National Park	Rank

- What ideas or activities do you have for making people see KNP in a more positive light?

(If participant has NOT mentioned crop raiding prevention) Would projects designed to deter crop raiding be appreciated? Yes/No

9. Do you experience crop raiding from animals in the park? Yes/No; If Yes, which species (confirm species using photoboard)
10. In the last harvest season, how many times did animals from the park crop raid in your garden?
11. What do you do when you see these animals in your garden?
12. How far onto your land do animals come to crop raid? _____
13. Is your land near a trench? _____
14. Do you have idle land? Yes/No If yes, why is it idle? _____
15. Are you involved in any existing community projects? Yes/No (e.g., the libraries project, bees project, etc.) If yes, which ones?
16. How interested are you in participating in a project to reduce crop raiding in your garden? (Not at all, Maybe, Very interested?)
17. What activities would you be willing to try on your land to reduce crop raiding?

(If not mentioned:) Would you be willing to try planting a buffer crop like tea? Yes/No Coffee? Yes/No Unpalatable crops? Yes/No Leaving land idle? Yes/No Keeping bee boxes? Yes/No Other?

18. How much space (meters) could you use for trying methods for reducing crop raiding? _____
19. Can we follow up with you to discuss project ideas further? Yes/No; If yes, how may we contact you in future? _____

APPENDIX B.: PHASE II SURVEY

Interviewer: _____ Date: _____
 _____ Household
 ID: _____
 Age: _____ Sex: _____
 _____ Occupation: _____

 Location: (circle one) Isule, Nyabinyungu, Kanyansohera, Kyamaguara

1. Does your land share boundaries with the park? Yes/No
2. What is the distance (in meters) from park boundary to the garden? _____m
3. How big is your land? _____ Do you rent or own it? _____
4. What is your current attitude about Kibale National Park? (Neg, Pos, Neutral, other?)

5. What do you think is the attitude of the community toward KNP? (Neg, Pos...)
6. Could you please tell us what are some of the benefits this household receives from living close to the Park? Please rank based on how important they are for this household (“based on their magnitude”)

Benefits of living next to Kibale National Park Rank

7. Could you please tell us what are some of the negative effects this household receives from living close to the park? Please rank based on their magnitude for this household.

Negative effects of living next to Kibale National Park Rank

8. Do you experience crop raiding from animals in the park? Yes/No; If Yes, which species
9. In the last harvest season, how many times did each of these types of animals from the park crop raid in your garden?
10. What crops do you plant? _____
11. Which of your crops do the animals eat (which animals)? _____
12. How much damage have they done? _____
13. How far onto your land do animals come to crop raid? _____
14. Is there a trench at the park boundary where you live? _____
15. Do you have idle land? Yes/No If yes, why is it idle? _____
16. To stop crop raiding, would you be willing to try planting tea as a buffer crop along the boundary of the park? Yes/No Comment:
17. Are you willing to plant the tea very close together to create a barrier for animals to pass through it? Yes/No Comment:

18. How much space (meters) could you use for trying methods for reducing crop raiding?
Comment:
19. Would you be willing to be part of a bee-keeping association and keep bee hives to reduce crop raiding? Yes/No Comment:
20. Would you be willing to help maintain the trench to reduce crop raiding? Yes/No; Comment:
21. Are you interested in planting garlic as a cash crop to off-set the losses from crop raiding? Yes/No
Comment: