

Full Length Research Paper

Farmers' perceptions of the effectiveness of strategies for managing wildlife crop depredation in Ghana

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Wildlife crop depredation represents a serious human-wildlife conflict around protected areas globally. It undermines farming livelihoods and local support for long-term conservation. Though studies have focused on different aspects such as the economics, spatiotemporal and vulnerability of farms to crop depredation, little attention has been given to the farmers' evaluation of the effectiveness of the strategies used to manage crop depredation. This paper aimed to examine the strategies used to manage wildlife by smallholding farmers who are among those closest to national parks, and how they evaluate the effectiveness of the strategies around Bui National Park in Ghana. Data were collected using semi-structured interviews, involving 17 farmers from Makala community living close to the park. The results indicated that farmers apply a single strategy and/or a multiple strategies, to manage crop depredation. The single strategy is generally ineffective in the long-term, but short-term and temporary successes were observed. However, farmers sought effective results by using strategies in different combinations depending on the major crop cultivated, the wildlife diversity involved, and the frequent experience of farm damage. Understanding the effectiveness of the strategies provides knowledge about how the strategies could be made effective against crop depredation to protect farms and facilitate local support for wildlife conservation.

Key words: Crop depredation, wildlife species, effectiveness, human-wildlife conflict, strategies, protected areas.

INTRODUCTION

Protected areas are the cornerstone of conservation around the world, covering over 32 million square kilometers, and representing about 15% of the world's land area (Juffe-Bignoli et al., 2014). They provide benefits to close communities, including income and employment through tourism (MacKenzie et al., 2017). However, their creation has also resulted in issues such

as displacement of local communities, loss of extraction rights, losses due to wildlife interferences with livelihoods, inadequate compensation for losses, and human fatalities resulting from human-wildlife interactions (Namukonde and Kachalic, 2015; Ango et al., 2017). Among these, crop depredation by wildlife is a primary driver of human-wildlife conflicts (HWCs) around protected areas (Salerno

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et al., 2014; Goswami et al., 2015; Anand and Radhakrishna, 2017). This conflict has significant consequences for the communities' farming livelihoods as it causes food insecurity, economic loss and increases income poverty (Kaswamila et al., 2007; Mackenzie and Ahabyona, 2012). As such, it has been a source of a long-standing grievance, decreasing communities' tolerance for wildlife conservation (Hill and Wallace, 2012). The communities often respond by actions such as injuring or killing these wild animals, thus creating conflicts with wildlife authorities and undermining conservation efforts, particularly when wildlife are becoming vulnerable to extinction (Palita and Purohit, 2008).

Crop depredation is expected to intensify with the increasing human-dominating landscape through farming near protected areas (Dakwa et al., 2016). Impoverished communities engaged in farming livelihood around protected areas will experience heavy crop losses, undermining household food security (Nyamwamu, 2016). As a result, crop depredation has emerged as a major food security concern around protected areas as it undermines the role of protected areas to adequately engage with the important United Nations Sustainable Development Goals of ending poverty and hunger.

Studies on crop depredation are extensive and diverse. The central focus of some studies has been to investigate the patterns and spatiotemporal correlates of crop damage so as to better inform conflict management strategies (Hsiao et al., 2013; Karanth et al., 2013; Ango et al., 2017). Other studies have focused on economics (Kaswamila et al., 2007; Mackenzie and Ahabyona, 2012), benefits, problems and solutions (MacKenzie et al., 2017), vulnerability of farming to crop depredation and the technical effectiveness of management strategies through field verification (Vollrath and Douglas-Hamilton, 2002; King et al., 2009). Other studies have focused on specific species like elephants and the strategies for managing them (Mackenzie and Ahabyona, 2012; Seifu and Beyene, 2014). Some focus on strategies, including lethal control such as regulated hunting in developed countries where legislation is strong (Bisi et al., 2007; Strum, 2010), and selective removal of identified problem animals through government intervention (Gurung et al., 2008). Other studies report of strategies such as increasing the size of buffer zones, fencing, human patrols, use of scares and repellents, and barriers (McGuinness and Taylor, 2014; Ango et al., 2017). Particularly, small-scale farmers in Africa use strategies such as crop guarding, hunting, burning, traps, snares, hedges, use of dogs and bees as an 'eco-deterrent' against wildlife depredation (Hill, 2000; Vollrath and Douglas-Hamilton, 2002; Sitati et al., 2005). Other strategies are identified as serving as incentives to support conservation. These include trophy hunting, planting agro-forestry buffers and non-palatable crops, as well as financial assistance to support non-farm projects

such as ecotourism, to ease dependency on protected areas (Leader-Williams and Hutton, 2005; Sitati et al., 2005; Kaswamila et al., 2007). In the literature, it is also argued that some strategies are unsustainable and illegal. For instance, Rusch et al. (2005) identified that the use of fire was common in Serengeti and is incompatible with conservation. With regards to the compensation payment for loss due to crop damage, it is viewed as an effort to increase community tolerance of problem species (Madhusudan, 2003; Naughton-Treves et al., 2003; Schwerdtner and Gruber, 2007). However, it is also argued that compensations have often led to a neglect of preventive measures or made people dependent on payments (Bulte and Rondeau, 2005). Even with this, bureaucratic inadequacies and practical barriers in filing complaints were reported to have resulted in an additional transaction cost for the rural poor, often discouraging them from pursuing it (Ogra and Badola, 2008; Seifu and Beyene, 2014).

Even though recent studies focus on the hidden dimensions of HWC (e.g., Barua et al., 2013), studies exploring the crop depredation management strategies and their effectiveness from farmers' perceptions are limited worldwide as most studies have focused on strategies, quantifying of crop damage and suggesting solutions rather than sharing what works and what does not in terms of reducing crop damage by wildlife species. Ignoring farmers' perceptions for improving strategies would undermine their food security and further engender negative attitudes towards wildlife conservation. According to Madden and McQuinn (2014), effective management of crop depredation is an essential precondition for the coexistence of farmers and wildlife. Also, it would help address food security around conservation areas (Adams, 2012). This paper aimed to examine strategies used to manage wildlife crop depredation by smallholding farmers that are among the most vulnerable who live near to conserved areas, and how they evaluate the effectiveness of the strategies around a protected area in Ghana. The purpose was to stimulate the policy-makers and management of protected areas to support the design of locally appropriate and effective management strategies that would reduce wildlife crop depredation, enhance food security and improve protected areas-community relationship.

MATERIALS AND METHODS

Study area

The study was undertaken in Makala community close to the Bui National Park in Ghana. It is located in the Banda District in Brong Ahafo Region lying within latitudes 7° and 8° 45' North and longitudes 2° 52' and 0° 28' West. An estimation of 78.6% of the population in the District engages in subsistent farming, with crop farming as the main agricultural activity (Ghana Statistical Service, 2014).

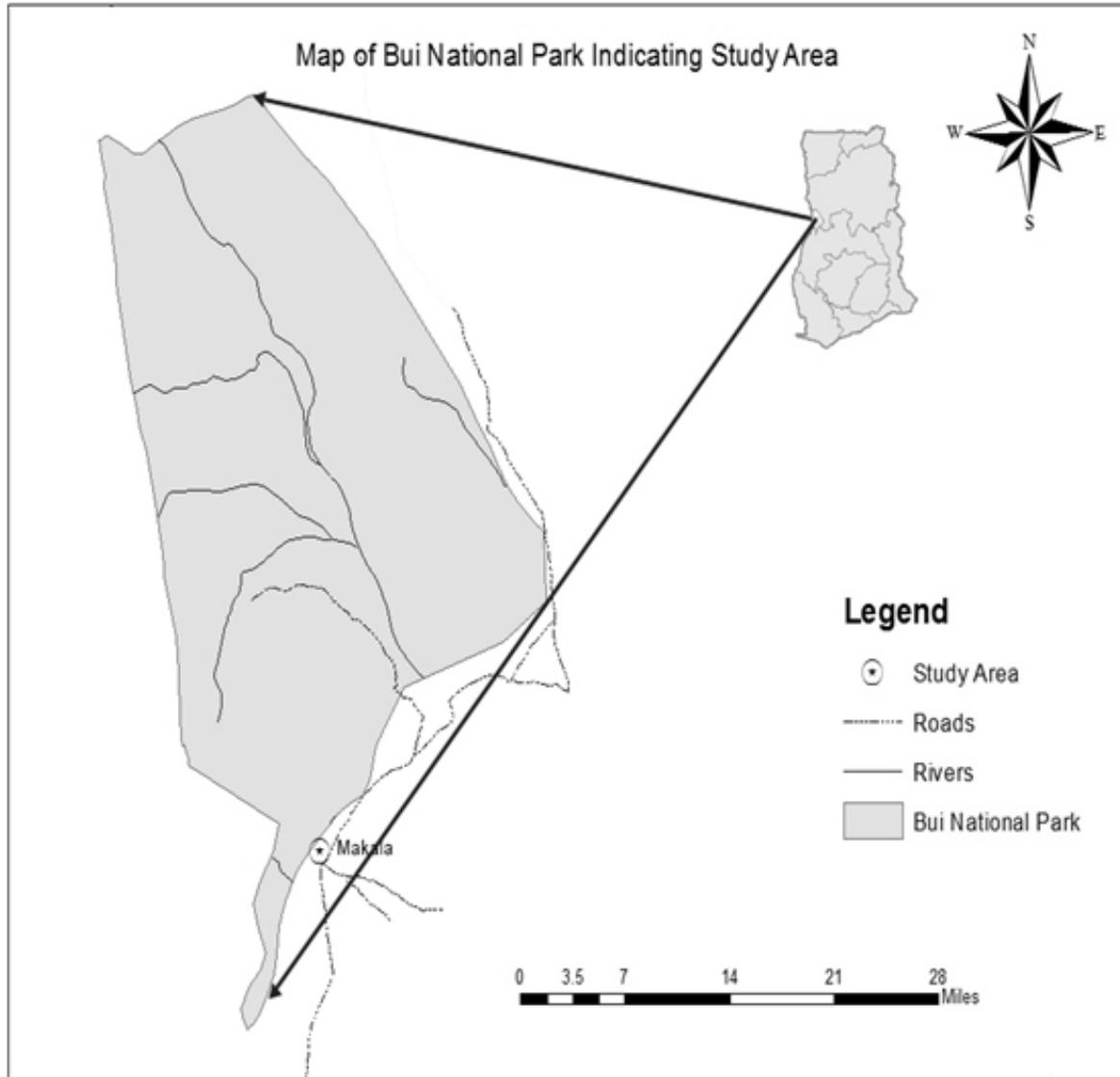


Figure 1. Map of Bui National Park showing Makala.

The temperature is generally high averaging about 24.5°C and the average rainfall regime is between 1,140 and 1,270 mm. The relative humidity is quite high averaging about 75% per year. These conditions account for the moist semi-deciduous forest and the guinea savannah woodland vegetation character of the area. It also accounts for the agrarian livelihood lifestyle of the community. The community has an average household size of 5.5 persons, coupled with a high level of poverty (Ghana Statistical Service, 2014).

In 2009, a government-sponsored hydroelectric power project dammed the Bui Volta River. This has created a lake, covering an area of 444 km² which accounts for an estimated 23% of the total area of the park which is now submerged, altering the ecology and displacing the wildlife to areas outside the park, including farms (Monney et al., 2010). The proximity of Makala community to the park (Figure 1) explains the experience of recurring crop damage on farms. This phenomenon is not only undermining local farming livelihoods and food security but also engendering negative attitudes towards wildlife conservation (Monney et al., 2010; Binlinla et al., 2014).

Case study approach

This study used a qualitative case study approach to examine the perceptions of farmers about strategies for managing crop depredation and their effectiveness, by relying on multiple sources of evidence to provide a clear understanding of the experience rather than generalizing findings (Veal, 2006; Yin, 2011). Most often than not, studies on crop depredation have used surveys based on predetermined categories of responses (e.g., Kaswamila et al., 2007; Monney et al., 2010) ignoring farmers' perceived reality of the experience. In this regard, Hill (2004) recommended assessing farmers' perceptions of crop depredation. As such, Makala, a farming community, was selected as a case based on the following criteria: (1) close proximity to Bui National Park; (2) Household dependence of subsistence agricultural farming for survival; and 3) Prevalence of wildlife crop depredation. These criteria reflect the merit of conducting a study in terms of collecting relevant data, and making the findings relevant to the farming community, Ministry of Food and Agriculture, District Assembly, and Wildlife Division of

Forestry Commission, interested in identifying effective and locally appropriate strategies to ensure household food security and foster local support for wildlife conservation in the locality.

Recruitment of research participants

After obtaining all the necessary permissions from the chief and elders of the community, farmers were recruited using purposive sampling. It was used as the sampling procedure in selecting farmers who have had, and are experiencing, crop damage by wildlife (Veal, 2006). This sampling method was supplemented with snowball sampling, where the initial participants helped to locate other farmers whose farms are nearby (that is, less than 1 km) to Bui National Park and who experienced crop depredation. Seventeen out of 30 farmers targeted for the study responded to participate. The study was conducted in June, during the raining season when farmers were busy preparing their lands for cultivation. They often leave home before 6 am and return after 5 pm. As a result, the other farmers could not participate, because they were either not available or did not have the time to participate in the study. It is worth noting here that, the farmers shared common experiences and not interviewing the other 13 farmers was not likely to significantly affect the nature of the data obtained as data from the four informants were used to understand and validate the experiences of farmers around the protected area. The ages of the farmers ranged from 27-78 years and all were married. As a tradition, men farm with their wives and it was required that they provide farming experiences. Also, key informants such as the chief, and representatives from Ministry of Food and Agriculture (MOFA), District Assemblies, and Bui National Park, were selected and interviewed prior to the engagement with the farmers. They provided background information on farming practices, crop depredation incidences, and local strategies for managing crop depredation in the area. Other secondary sources of information such as reported crop depredation and local attitudes towards wildlife conservation were sought. These sources guided the questions posed during the interviews with the farmers and also used to validate and probe relevant issues during the interviews.

Data collection

In collecting the data, semi-structured interviews were used to elicit farmers' perceptions of the strategies and their effectiveness. According to Brinkmann and Kvale (2015, p. 6), a semi-structured interview is defined as "an interview with the purpose of obtaining descriptions of the lifeworld of the interviewee in order to interpret the meaning of the described phenomena". The interviews were conducted in the house of farmers where they felt comfortable. Farmer's participation was voluntary and verbal consent was sought from each one before conducting and recording the interviews with a tape recorder. Each interview was then downloaded onto a laptop for safekeeping before the next interview. Confidentiality and anonymity were ensured by the use of pseudonyms for all the farmers involved. Interviews were conducted in the local language (that is, Twi dialect) familiar with both the researcher and participants. On average, each interview lasted for 40 min. Farms were also visited to observe the strategies used and gain an understanding of the level of the effectiveness of the strategies. The fieldwork lasted for four weeks in the month of June 2016.

Data analysis

The recorded interviews were initially translated from the local language (that is, Twi) to the English language. These were then transcribed and all grammatical corrections made before saving

them as word documents. These were further uploaded into Nvivo 9, which served the functions of supporting the storing, retrieval and manipulation of texts or documents as well as supporting the creation and manipulation of nodes. Using Nvivo 9, the texts were disassembled or broken down into smaller fragments by assigning labels or codes to the fragments in a process called coding. These fragments were reassembled into themes based on the emerging patterns in the texts (Yin, 2011). The themes emerging from the texts were supported by relevant quotations that represent and justify these themes as discussed in the results part.

RESULTS

Livelihood vulnerability to crop depredation

All the farmers practiced subsistent farming with farm holdings (that is, less than 1.6 ha) located close to the park (that is, less than 1 km). Mixed cropping is the norm but the major food crops cultivated were cassava, yam, cocoyam, groundnut, maize, beans, tomatoes and pepper. Cash crops such as cashew and gourd were identified as well. Yam, cassava and cashew were the most major cultivated crops. Farmers depended heavily on farm produce to feed their households and surplus crops are sold for income to support other household needs such as hired labour, school fees and other food crops not planted.

The interviews revealed three factors explaining farms vulnerability to crop depredation. These were: (i) proximity to the boundary, (ii) wildlife displacement because of increasing submerging areas of the park and (iii) wildlife food preference. Farming close to the boundaries of the park exposed farms to regular wildlife attacks. For instance, Kontoh narrated that: "My farm is close to the park and animals find it easy to come and destroy the food crops". This is a common experience of all the farmers. Interestingly, they claim that they farm close to the boundary because of limited access to fertile land elsewhere. Also, the damming of the Bui Volta River in the park has submerged about 23% of the total area of the park, destroying wildlife habitats. As a result, farmers perceived that animals are forced out of the park to their farms, because of limited grazing grounds for the wildlife species. Zellem, who has lived in the community for over 50 years, claimed he now encounters more wildlife in his farm than before; attributing this observation to the rising water level in the park.

The feeding behaviour of wildlife is perceived to have changed due to long exposure to cultivated crops close to the park. Farmers claimed that as the animals feed on the crops, they have changed their feeding behaviour and developed a preference for cultivated crops. They have become selective with the kind of food they eat as they raided farms with such food crops. For instance, Abel shared his experience when he narrated that; "They like the food crops I grow especially the yam and cassava. It is only the food crops on my farm they destroy always". Interestingly, farmers are not changing the cultivation of these food crops because they are their main sources of

Table 1. Wildlife species identified as causing crop depredation.

Common names	Scientific names	Encounter	Frequency	Damage
Bushbuck	<i>Tragelaphus scriptus</i>	Footprint/droppings	Low	Medium
Patas Monkey	<i>Erythrocebus patas</i>	Direct encounter	High	High
Green Monkey	<i>Chlorocebus sabaeus</i>	Direct encounter	High	High
Partridge	<i>Perdix perdix</i>	Direct encounter	High	High
Ground Squirrel	<i>Spermophilus</i> sp.	Direct encounter	High	High
Cane rat	<i>Thryonomys swinderianus</i>	Direct encounter	High	High
Buffalo	<i>Bison bison</i>	Footprint/droppings	Low	Medium
Porcupine	<i>Erethizon dorsatum</i>	Footprint/droppings	Low	Low
Francolin	<i>Francolinus francolinus</i>	Direct encounter	Low	Low
Brown Rat	<i>Rattus norvegicus</i>	Direct encounter	High	High
Red forest duiker	<i>Cephalophus natalensis</i>	Footprint/droppings	Low	Low
Red flank duiker	<i>Cephalophus rufilatus</i>	Footprint/droppings	Low	Low

Table 2. Techniques used to manage crop depredation.

Techniques	Detail description	Period
Scarecrow*	Forming human looking structures to scare animals	Not specific
Guns**	Used for giving warning shots or killing problem animals	Not specific
Traps**	Use of metals, wires and wood as traps for animals	Not specific
Repellents*	Dirty oil is sprinkled on food crops to make them unpalatable	Not specific
Noise*	Shouting by farmers/use of noise-making metals to scare animals	Not specific
Farm guards*	Farmers guard or hire guards to protect farms in the night	Night
Dogs*	Dogs are trained to chase animals off the farms	Day
Fire**	Wood is burnt to produce smoke that drives animals	Night
Touch lights*	They are switched on throughout the night in the farm	Night
Radios*	Are played throughout the day on farms to scare animals	Day
Catapults*	Used for giving warning shots or killing problem animals	Day

1. *: Acceptable 2. **: Prohibited.

income. The experience of crop damage reduces household food reserves and income expected from harvest. A farmer lamented that the recurring wildlife damage to their farms limits their abilities to cater adequately for needs such as feeding their children and paying their school fees, because they are not compensated for crops damaged.

Wildlife causing crop depredation

Farmers identified a number of problem wildlife animals causing crop depredation. They based their identifications mainly on observations of footprints and droppings, though there were direct encounters of animals on farms. In all, 12 wildlife species were identified. However, the monkeys, antelopes, rats and the ground squirrels were described as very destructive by farmers and were ranked high, while the others were ranked either low or medium in terms of the perceived level of farm damage caused and frequency of encounter (Table 1).

Based on the interviews, farmers indicated that the level of damage caused by monkeys, antelopes, rats and the ground squirrels is because they visit farms often and/or in their excessive numbers. They uproot and destroy the yam, cassava and groundnut plants. Animals like buffaloes, duikers and porcupine are lone species that only browse the leaves of the cultivated crops. They also cause damage through trampling on the cultivated crops such as groundnut, beans, tomatoes and pepper. They are not often encountered. The other animals, mostly birds, visit often and in high numbers. They feed on ripped corn and the level of damage can be worrying to farmers during harvesting.

Strategies for managing crop depredation

Farmers' have developed strategies for managing crop depredation, targeted at problem wildlife species (Table 2). The strategies that are adopted aimed at deterring, capturing, or killing the animals. Two major strategies

Table 3. Wildlife and strategies for controlling damage.

Common names	Strategies
Bushbuck	Trap/guns/repellent/fire
Patas Monkey	Trap/gun/ guards /catapult/noise
Green Monkey	Trap/gun/ guards /catapult/noise
Partridge	Scarecrow/catapult/radio/noise
Ground Squirrel	Trap/catapult/radio
Cane rat	Trap/gun/repellent/catapult/dog
Buffalo	Trap/gun/repellent/fire
Porcupine	Trap/catapult/radio
Francolin	Trap/catapult/radio
Brown Rat	Trap/gun/repellent/catapult/dog
Red forest duiker	Trap/gun/repellent/fire/guards
Red flank duiker	Trap/gun/repellent/fire/guards

observed were: single technique strategy and multiple technique strategies. Both strategies are locally designed and rudimentary techniques applied in either singly or different combinations depending on the problem wildlife species that are causing damage, the frequency of wildlife encounter, major cultivated crop, and the perceived level of farm damage (Table 3). For instance, where the major cultivated crop was maize, the scarecrow or noise-making using metals were the single technique used, even though some farmers coupled it with catapults and radio which mimic human presence and deterred animals, preventing depredation during the day. Farmers noted learning from other farmers who were using an effective technique for an identified animal. For instance, the application of a single technique can be a knowledge acquired from another farmer using it. According to Joe, "I use pieces of metals on sticks, placed in different places in my maize farm to drive away birds. Another farmer who is a friend showed me this strategy". Also, a typical case was some farmers learning that gas oil sprayed on the leaves of plants reduced browsing. However, where farmers practiced mixed cropping and were exposed to a variety of problem wildlife species, the use of a multiple technique strategy was the norm.

The use of some techniques is a period of time specific. While some farmers use radios and dogs during the day, others use fire, torchlight, and farm guards to deter and prevent depredation during the night. Techniques such as the use of guns, chemical repellent and traps are commonly used but not a period of time specific. The chemical repellent is commonly used in farms, particularly vegetable farms, where either the leaves or fruits of the cultivated crops are the preferred food by wildlife but not humans

Some of the techniques are acceptable while others (such as traps, fire and guns) are prohibited by the park management because of their fatality on the wildlife species and the potential of inducing poaching behaviour

among farmers in the locality (Table 2). These techniques are used to harm, immobilize or kill animals to prevent further depredation. Particularly, the use of guns to harm or kill wildlife species is strongly prohibited by park management. However, the use of guns is attributed to the experience of frustration from the destruction of crops. Particularly, the monkeys, antelopes, rats and ground squirrels were found to be very destructive by farmers. They were subjected to different unacceptable techniques to reduce the damages they cause. Interestingly, most identified problem animals are subject to multiple techniques despite the major crop on farms (Table 3).

Effectiveness of strategies

The effectiveness of the strategies used in managing wildlife crop depredation was evaluated by farmers in terms of the efficacy in the use of a single technique, or in combination depending on the major crop cultivated, the animals perceived to be causing damage and the frequency of wildlife encounter and perceived farm damage. They considered a strategy to be effective when farm damage is reduced to a perceived tolerable limit as farmers agree that crop damage cannot be prevented.

Generally, the use of a single technique strategy is viewed as ineffective in the long-term because of the exposure of the farms to a variety of wildlife species and the recurrent nature of farm damage. The extent of damage can be worrying to farmers as it affected household food reserves and expected income from harvest. The ineffectiveness of the single technique is also based on the temporality of the technique in deterring wildlife from the farms as farmers claimed that wildlife species learn to avoid or maneuver around the techniques. However, short-term and temporary successes were observed with this strategy. For instance, farmers noted that the use of scarecrows, traps, fire, and

Table 4. Evaluation of the effectiveness of strategies in scenario agrosystem (major crop).

Major crop	Strategies	Animals	Effectiveness
Maize	Scarecrow	Birds	Less effective
Yam	Traps	Rat	Less effective
Cassava	Traps	Duikers/antelopes	Less effective
Vegetables	Repellent	Duikers/antelopes	Less effective
Maize	Scarecrow/ noise-making /radio	Most animals	Effective
Yam	Traps/gun/repellent/catapult/dog	Duikers/antelopes	Effective

effective in the short-term as each is able to reduce the frequency of wildlife encounter and farm damage. But these techniques need to be coupled with others to ensure a good harvest. In effect, they pointed to the evolutionary applications of techniques, initially from a single technique to multiple techniques as a result of identifying other problem animals in the farms over time. This trend is based on farmers learning from others, who have been a success with techniques against certain problem wildlife. For example, Kwame explained that he was not successful in reducing damage to his maize farm until he was introduced to the use of radio as an effective technique, particularly in the day, against birds.

The application of a multiple technique strategy is viewed as an effective strategy because, in both the short and long-term, multiple techniques reduce the frequency of wildlife encounter and farm damage through the harnessed combined effects of the techniques. Farmers sought for effective results by using these techniques in different combinations depending on the major crop cultivated, the diversity of species involved, and the frequent experience of farm damage (this is explained using agrosystem scenarios as shown in Table 4). As such, a multiple technique strategy is now the norm (because of the different mixed cropping systems in the locality) in order to reduce crop damage and ensure food security. This strategy is also evolutionary as farmers learn from others using effective techniques to combat wildlife species.

DISCUSSION

Subsistence farming livelihoods of local communities around the protected area are exposed to recurring crop depredation by wildlife species. Such vulnerability results from proximity to the boundary, wildlife displacement and wildlife food preference. In sustaining such livelihoods, farmers have developed strategies to manage the wildlife crop depredation. Wildlife species such as monkeys, antelopes, rats and the ground squirrels were viewed as very destructive, because of the high numbers involved and frequency of damage associated with them. Even though other problem animals were reported in other studies, monkeys seem to be a single wildlife species

commonly reported as problem animals on farms (Ango et al., 2017; MacKenzie et al., 2017). For instance, Ango et al. (2017) who studied human-wildlife conflict in an agri-forest landscape in Ethiopia also identified monkeys as one of the crop destructive wildlife. As found in this study, farmers use prohibited techniques to manage them.

In struggling to ensure food and income security, despite the rudimentary nature of the strategies, farmers often apply either single or multiple combinations of techniques depending on the major cultivated crops, diversity of problem animals from the park, and frequency of wildlife encounter and perceived farm damage. Single technique strategy on a farm is a planned intervention, dictated by a foreknowledge of a common problem wildlife species. However, this study demonstrated that the single technique strategy is generally perceived as ineffective in the long-term because of the recurrence of crop depredation even though temporary successes were observed. This is consistent with a study in Bardia National Park by Thapa (2010), who reported that communities deployed techniques that are effective, but just for a short period. The general observation from years of studies on crop depredation suggests that wildlife damage is still prevalent around protected areas, giving reasons such as technical faults, high capital requirement, poor cooperation among farmers, lack of commitment of the farmers, and limited resources (Osborn and Parker, 2003; Graham and Ochieng, 2008; Ango et al., 2017). However, the ineffectiveness of this single technique strategy is explained by the application of stand-alone techniques requiring low capital investment and expertise typical of poor farmers. Interestingly, the study found that the single technique strategy may evolve into a multiple technique strategy based on the transfer of local knowledge. Such local knowledge has become instrumental in cases where single techniques strategy is ineffective in reducing crop damage to a tolerable limit. Such observation was found to be a reactive behaviour dictated by the encounter of more problem animals on farms over time.

Generally, multiple technique strategy is found to be a norm because of the practice of mixed cropping systems, which attract a variety of wildlife species. The strategy is effective because the harnessed combined effects of the techniques deters a variety of wildlife species in the long-

term and reduces the level of farm damage within a perceived tolerable limit that guarantees food and income security to farmers. These findings contradict other studies in which farmers' evaluation were based on two indicators: (i) animals should be kept away from damaging or eating the crops and (ii) the strategy should be easy and cheap to maintain (King et al., 2009; Hsiao et al., 2013). This study, however, differs because of the elements of farmers' perceived period of effectiveness (that is, long-term) and the limit of farm damage for determining the effectiveness of the two strategies. Though the techniques are traditional and rudimentary, the multiple technique strategy seems to work for the farmers and may help support food security concern around protected areas in Africa as enshrined in the important United Nations Sustainable Development Goals of ending poverty and hunger. However, it raises uncertainty about local support for wildlife conservation as the strategy include the use of prohibited but fatal techniques emanating from frustration relating to a recurrence of crop depredation and lack of compensation for crop losses. Even though some studies suggest that the use of such fatal techniques are often unsustainable, have limited effects and undermine conservation efforts (Rusch et al., 2005; Tweheyo et al., 2005; Holmern et al., 2007), this study found otherwise. The use of fatal techniques such as chemical repellent, fire, traps and guns, though considered illegal or prohibited around the protected area, is particularly appealing to farmers as they acknowledge their efficacies in deterring wildlife against crops in the long-term.

Conclusion

Crop depredation is prevalent human-wildlife conflict around Bui National Park. With this conflict expected to intensify, it may pose serious threats to subsistent farming of communities around the park. Because of the heavy dependence on farming livelihoods, farmers have evolved dual strategies that are traditional but integrative, to manage crop depredation to reduce crop losses and ensure food and income security. The single technique strategy is generally ineffective based on the recurrence of the conflict, though short-term and temporary successes were observed. This strategy is also found to evolve into multiple technique strategy. The use of this strategy reflects a farmer's reactive behaviour supported by the transfer of local knowledge. The multiple technique strategy is a norm, because of the common practice of mixed cropping that attracts a variety of wildlife species. It was observed to be more preferable and effective in the short and long-term as the harnessed and combined effects of the techniques deter a variety of wildlife species and reduce the level of farm damage within a perceived tolerable limit that guarantees food and income security after harvest. However, the use of some illegal strategies,

questions the certainty of local support for wildlife conservation and co-existence despite success with multiple technique strategy. With protected areas increasingly becoming embedded in the agricultural landscape, human-wildlife conflict is expected to increase as wildlife habitats are continuously being fragmented by farming activities. The prospects of engaging protected areas to achieve zero poverty and hunger will have to take into account local support for wildlife conservation by encouraging the wide application of a legal multiple technique strategy, which is effective. These strategies need to be supported and up-scaled by policy makers and park management because they are locally designed based on learning and required low capital and expertise, unlike the modern techniques which are beyond the capacity of poor farming communities around protected areas. As well, views of farmers concerning what they can do apart from farming should be explored in future studies to discourage farming near the boundaries of protected areas.

Limitations of the study

Strategies for managing crop depredation and the effectiveness of these strategies were investigated with the focus on farmers with the experiential reality of this phenomenon and farming close (less than 1 km) to the boundaries of a protected area. Farmers with similar or dissimilar experiences farming far away from the boundaries of the national park were not considered because this study sought to improve wildlife-community coexistence, food security and community attitudes towards wildlife conservation. However, their perceptions could have improved the exhaustiveness of the techniques in the locality and enriched the understanding of local evaluation of the effectiveness of the strategies. Also, how certain social factors such as gender, ethnicity and cultural beliefs mediate and shape this conflict and evaluation, were outside the domain of this study. These factors could have explained better the behaviours of farmers, for instance, the application of illegal strategies to manage crop depredation. Future studies are suggested to explore the role of social factors such as gender, ethnicity and cultural beliefs in shaping this conflict and evaluation of the effectiveness of techniques by other farmers beyond the boundaries of the park, to encourage locally evolved strategies likely to deliver long-term solutions to improve food security and coexistence between wildlife and farming communities within the context of the Sustainable Development Goals of zero poverty and hunger around protected areas.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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