

*Full Length Research Paper*

# The impact of crop raiding by wild animals in communities surrounding the Serengeti National Park, Tanzania

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**Crop damage is a serious source of conflict in communities adjacent to protected areas. Data on crop raiding were collected through questionnaires in villages at different distances from the Serengeti National Park in northern Tanzania. Multiple response analyses were used to calculate the frequencies of the types of crops damaged, the levels of crops growth when damaged and the estimated economic losses caused per household. The results indicate that crop raiding differed significantly on farms along a distance gradient from the protected area. Baboons were reported to be the most destructive wild animals, followed by elephants, which were destructive especially in the villages located near the protected area. Wild animals caused significant economic losses for households. We recommend further studies on the crop yield gap caused by crop-raiding wild animals and human-primate conflict in communities around protected areas. For effective protection of crops from wild animals, we recommend that local communities adopt a combination of methods to reduce the levels of crop raiding.**

**Key words:** Crop raiding, Serengeti ecosystem, human-wildlife conflict, wild animals.

## INTRODUCTION

Crop damage is defined as feeding on cultigens by wild animals that causes substantial financial losses to farmers (Saj et al., 2001; Gunn, 2009; Fungo, 2011) and is a serious source of conflict between local communities and the management of adjacent protected areas (Newmark et al., 1994; Ntalwila et al., 2003; Ogra, 2008; Malugu, 2010). It is becoming a worldwide and complex problem (Saj et al., 2001; Sillero-Zubiri and Switzer,

2001; Nyahongo, 2007). It affects subsistence farmers directly through the loss of their primary food and cash resources and indirectly through a variety of social costs (Osborn and Parker, 2003; Marchal and Hill, 2009). For example, crop raiding was reported to affect 40% of all crops planted in a farm in the Ruaha Ecosystem (Kabepelle, 2011) and cause an average annual crop loss per household of 11% of the household income in the

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Serengeti District (Kaswamila, 2007). In general, crop raiding is reported to be limited to a distance of a few hundred meters outside the protected areas, with fields further away receiving little or no damage (Hill, 2000; Gillingham and Lee, 2003; Ole Meing'ataki, 2005; Ntalwila, 2007; Sarker and Røskaft, 2011).

Crop raiding by wild animals is caused by several species ranging from large mammals to smaller animals, such as birds, rodents and insects (Saj et al., 2001; Rao et al., 2002; Osborn and Parker, 2003; Sitati et al., 2003; Gunn, 2009). The animal species most often cited as responsible for crop damage in regions surrounding protected areas in Tanzania include African elephants (*Loxodonta africana*) (Ntalwila et al., 2003; Kaswamila, 2007; Malugu and Hoare, 2007; Kikoti et al., 2010; Malugu, 2010), primates (Ntalwila et al., 2003; Kaswamila 2007), bushpigs (*Potamochoerus porcus*) (Newmark et al., 1994; Ntalwila et al., (2003), dik diks (*Madoqua kirkii*) (Ntalwila et al., 2003), bushbucks (*Tragelaphus scriptus*) (Ntalwila et al., 2003), rodents (Newmark et al., 1994), African porcupines (*Hystrix cristata*) (Ntalwila et al., 2003), vervet monkeys (*Chlorocebus pygerythrus*) (Ntalwila et al., 2003) and Cape buffalos (*Syncerus caffer*) (Ntalwila et al., 2003).

Crop raiding may peak during the harvest season when the crop is mature (Parker and Osborn, 2001; Malima et al., 2005; Jackson et al., 2008; Gunn, 2009; Malugu, 2010), but it commonly occurs throughout the year (Walpole et al., 2004; Malugu and Hoare, 2007; Gunn, 2009; Ntalwila et al., 2011). Mature crops may offer a high nutritional benefit to the raiding wild animals (Malugu and Hoare, 2007) and are also the most palatable and contain most calories, reducing herbivore feeding time (Ntalwila et al., 2011). Crops that are at the highest risk include cassava (*Manihot utilissima*) (Naughton-Treves, 1998), maize (*Zea mays*) (Naughton-Treves, 1997; Ntalwila et al., 2003; Walpole et al., 2004; Kikoti et al., 2010), sweet potatoes (*Ipomea batatas*) (Ntalwila et al., 2003; Walpole et al., 2004), groundnuts (*Arachis hypogaea*) (Naughton-Treves, 1997), sorghum (*Sorghum vulgare*) (Walpole et al., 2004) and finger-millet (*Eleusine coracana*) (Ntalwila, et al., 2003; Walpole et al., 2004). Other crops subject to damage are beans (*Phaseolus vulgaris*), bananas (*Musa acuminata*), tomatoes (*Lycopersicon esculentum*) and fruits (Ntalwila et al., 2003). According to Malugu and Hoare (2007), the crops most often raided in the western Serengeti in northern Tanzania are sorghum and maize.

Local communities have adopted several measures to deter crop raiding by wild animals. Some of the most common measures include guarding (Hill, 2000; Walpole and Linkie, 2007; Malugu 2010), making noises (Malugu, 2010), lighting fires at night, digging trenches against bush pigs (Kagoro - Rugunda, 2004; Fungo, 2011), and constructing fences (Paterson, 2007; Malugu and Hoare, 2009; Malugu, 2010; Fungo, 2011). These methods are used either individually or in combination. Selection of a

particular method depends on the size of the field, the crop being grown; guard labour availability and vulnerability of the crop to raiding (Fungo, 2011).

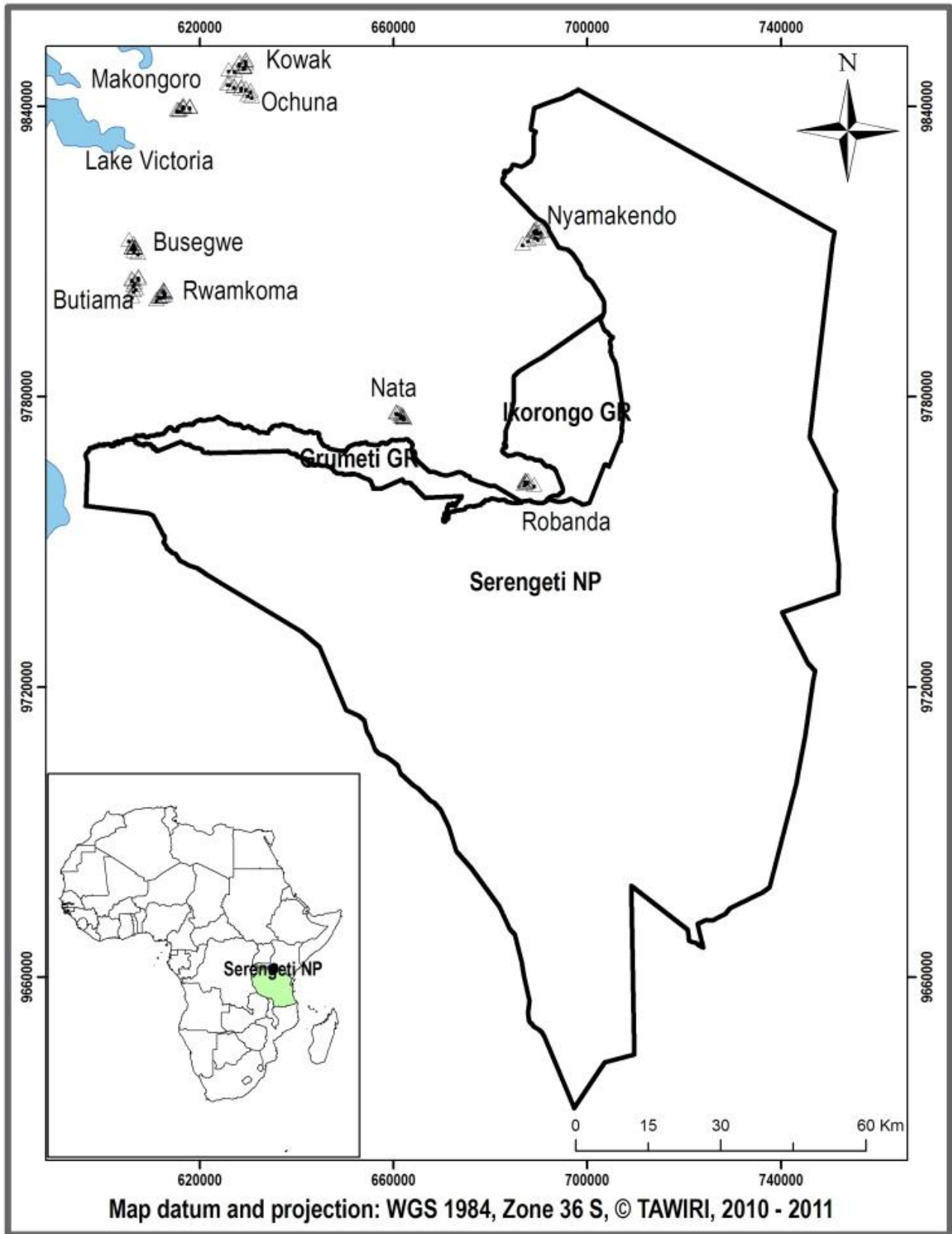
Expanding scientific knowledge regarding the nature and extent of human-wildlife conflicts is important because such conflicts tend to affect the livelihoods of people (Newmark et al., 1993). The monitoring of crop damage is largely limited to incident reports by local people to their local governments and later to the wildlife authorities in order for an appropriate action to be taken (Hoare, 1999). Most studies on human-wildlife conflicts are based on surveys examining perceptions of the problem held by local people. However, it is recognized that perceived and actual extent of such conflicts do not match. An exaggeration of the extent of damage is therefore the consequence (Naughton-Treves, 1998). In addition, careful documentation of economic losses is essential in order to assess the extent of damage. The present study intends to determine the extent of crop raiding by elephants, birds, primates, bushpigs and rodents in households along a gradient of distance from the protected areas in the Serengeti Ecosystem in northern Tanzania and to analyse the economic effects crop raiding has on different area at household level. We hypothesise that the amount of crop damage by wild animals per household per year is similar in villages adjacent to Serengeti National Park and in villages farther away from the park.

## METHODOLOGY

### Study area

The study area is located in the north-eastern corner of Tanzania, northwest of the Serengeti National Park (SNP) (Figure 1). The western Serengeti corridor extends westward to Lake Victoria (1°30' - 2°30' and 33°50'S - 34°45'E). The SNP is the central part of the greater Serengeti Ecosystem in the northern Tanzanian highlands. Rainfall in the Serengeti is seasonal and is determined by large-scale weather patterns, modified by local topography (Pennycuick and Norton-Griffiths, 1976). The rain normally falls in two seasons; the short rains from November to December and the long rains from late February until mid May (Hopcraft, 2010). There is a rainfall gradient from the dry southwest plains to the wetter northwest. Rainfall ranges from 514-688 mm per year in the southeast plains to 857-976 mm per year in the central woodlands and western corridor and 972-1100 mm per year in the north (Campbell and Hofer, 1995). It has been reported that, in many areas of Tanzania, crop raiding occurs mostly during rain seasons when crops are matured (Ntalwila et al., 2011). The monthly average maximum temperature in the western Serengeti fluctuates between 25 and 32°C (Campbell and Hofer, 1995). The minimum daily temperature ranges between 13 and 19°C.

People inhabiting this region are either agro-pastoralists or pastoralists. The human population in the area is estimated to be over two million (URT, 2012). The main ethnic groups in the study areas are Ikoma, Sukuma, Nata, Ikizu, Jita and Kurya. Local communities in western Serengeti pursue differences economic activities that include fishing, livestock rearing, game meat hunting and trading (Loibooki, 1997; Loibooki et al., 2002). Approximately 96% of the respondents in the Serengeti ecosystem depend on



**Figure 1.** Map of the study area showing Serengeti National Park, Grumeti and Ikorongo Game Reserves, Lake Victoria and the surveyed villages (Robanda, Nyamakendo, Nattambisso, Butiama, Busegwe, Rwamkoma, Ochuna, Makongos and Kowak) indicated with triangles.

**Box 1.** Research questions on crop raiding.

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1. Do you grow crops in your farm?
  2. How many cropping season do you have in the area?
  3. Have you experienced any crop raiding incidences in your farm for the last cropping season?
  4. How many incidences of crop raiding occurred in your farm for the last cropping season?
  5. What coping strategies do you apply to prevent your crops from being destroyed by wild animals?
  6. Mention type of crops damaged and type of wild animals responsible for the damage
  7. What was the growth stage of crop damaged by wild animals (seedling, flowering or fruiting)?
  8. What is the estimate of economic losses resulting from crop damaged caused by wildlife in percentages (%) and Tanzania Shillings (TShs) in the last cropping season?
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crop-based agriculture for their socio-economic development (Kaswamila, 2007). The crop cycle follows rain patterns. Maize, sorghum and millet are planted twice a year, in February-March and August-October, and the harvesting periods for the plantings are June-July and January-February, respectively. Livestock includes cattle, goats, sheep and poultry, although a few households keep pigs and donkeys. The western Serengeti District is one of the areas that are highly affected by massive attacks on field crops (Kaswamila, 2007).

**Data collection**

Data were collected throughout the year from January 2010 to December 2010 in nine selected villages along a gradient of distance from SNP. The selection of the villages in gradient was done in such a way that three villages were located within 10 km from the protected area (Robanda, Nyamakendo and Nattambisso), approximately 40 km (Butiama, Busegwe and Rwamkoma) and approximately 80 km from the protected area (Ochuna, Makongos and Kowak) (Figure 1). Crop raiding data were collected using the following techniques: key informant survey, group discussions, and questionnaires (Box 1). The questionnaire interviews covered a total of 459 households that were randomly selected from the village and sub-village registers. We interviewed household heads, their wives or resident adults ( $\geq 18$  years old). The villages and sub-villages were picked based on a random selection. In terms of gender, 36.2% of the interviewed respondents were females and 63.8% were males. The questions were both close-ended and open-ended and were aimed at extracting the respondent's opinion in an open minded atmosphere. The questionnaire was written to elucidate patterns of crop raiding incidences, type of crops damaged, type of wild animals responsible for the damage, estimates of crop losses and coping strategies against crop raiding. For each village, we selected ten households whose farms were monitored for crop raiding. We hired an enumerator in each village who recorded any crop damage within the project villages and other villages that were not selected. After any incidence involving crop damage, enumerators were instructed to record and report the events to the Village Executive Office where similar data were recorded and compiled.

**Data analysis**

Statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS, version 17). A multiple response analysis was used to calculate the frequency of damage to individual crop types, the developmental stage of plants when the damages occurred and the estimated economic loss due to crop

damage per household. Pearson Chi-square tests were applied to test the different independent variables in relation to distance from the protected area.

**RESULTS****Crop raiding by wild animals based on the distance from the SNP boundary**

Fifty four percent (54.3%) of respondents ( $n = 451$ ) reported crop damage caused by wild animals. The frequency of crop damage differed significantly among the surveyed villages along the distance gradient from the park (Pearson Chi-square:  $\chi^2 = 6.0$ ,  $df = 2$ ,  $n = 451$ ,  $P < 0.05$ , Figure 2). The percentage of farms that experienced crop damage was highest in villages that were closest to the protected area (Figure 2).

**Types of wild animals involved in crop raiding**

Wild animals involved in crop raiding differed significantly among the surveyed villages (Pearson Chi-square:  $\chi^2 = 446.1$   $df = 10$ ,  $n = 644$ ,  $P < 0.001$ , Figure 3). Baboons were reported to be the most destructive wild animals in the surveyed villages at middle and far distances from the park (36.8%,  $n = 644$ ). Elephants (35.1%,  $n = 644$ ) were especially destructive in the villages nearest to the protected area (Figure 3). Other wild animals reported to damage crops were birds, rodents, squirrels, bushpigs, warthogs and porcupines.

The types of crops damaged by wild animals differed significantly among the surveyed villages (Pearson Chi-square:  $\chi^2 = 41.7$   $df = 10$ ,  $n = 703$ ,  $P < 0.001$ , Figure 4). Maize was the crop with the most reported damage (38.8%,  $n = 703$ ), while sorghum was the second most affected crop (25.7%,  $n = 703$ ). Other crops that experienced damage by wild animals were cassava, potatoes, finger millet, groundnuts and beans. The developmental stage of the damaged crops differed significantly (Pearson Chi-square:  $\chi^2 = 27.8$   $df = 6$ ,  $n = 213$ ,  $P < 0.001$ , Table 1). Crop-raiding was most intense during harvest time when crops were mature (47.9 %,  $n =$

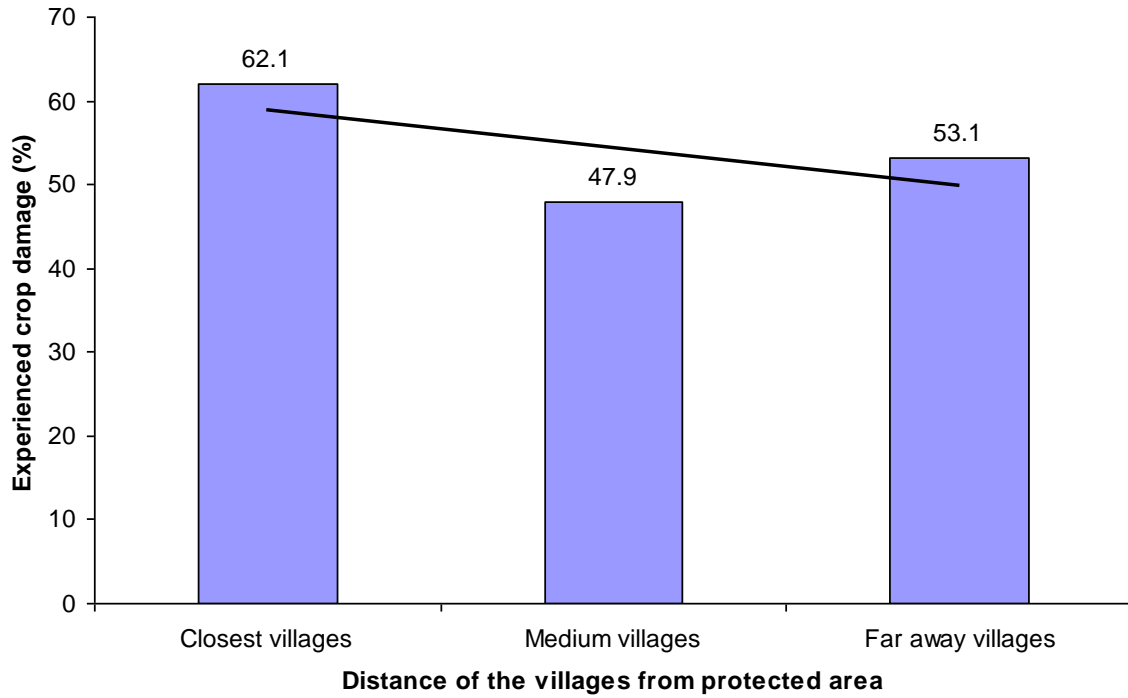


Figure 2. Percentage of households experiencing crop damage in the surveyed villages.

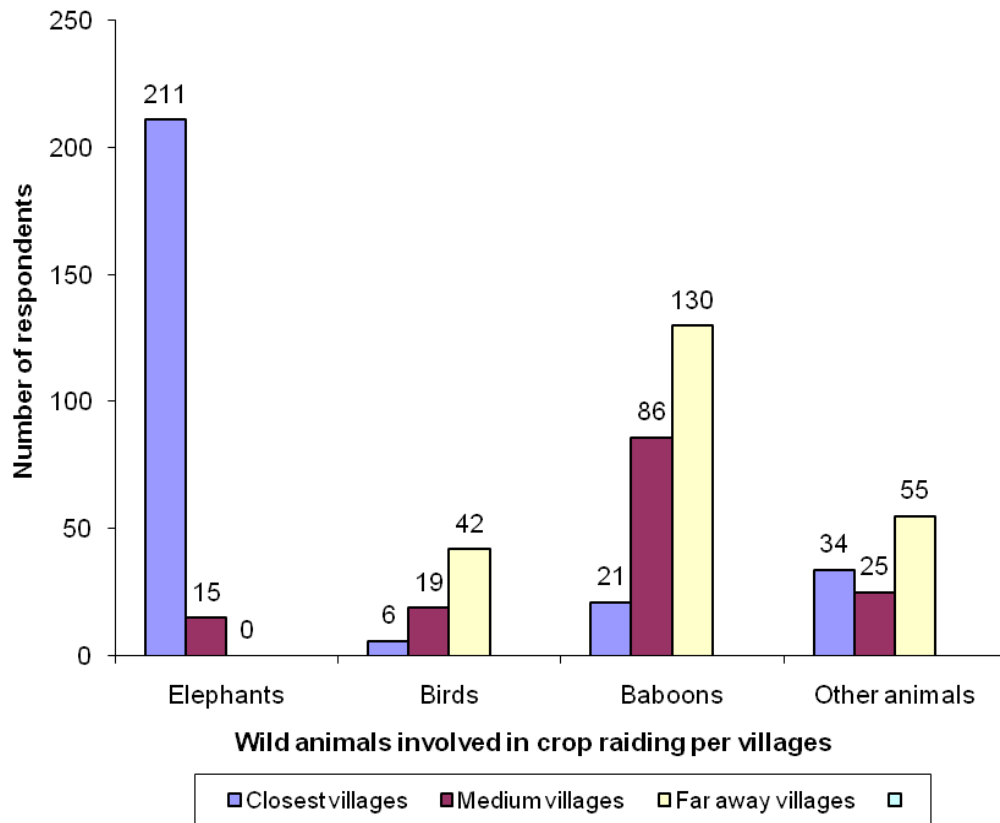
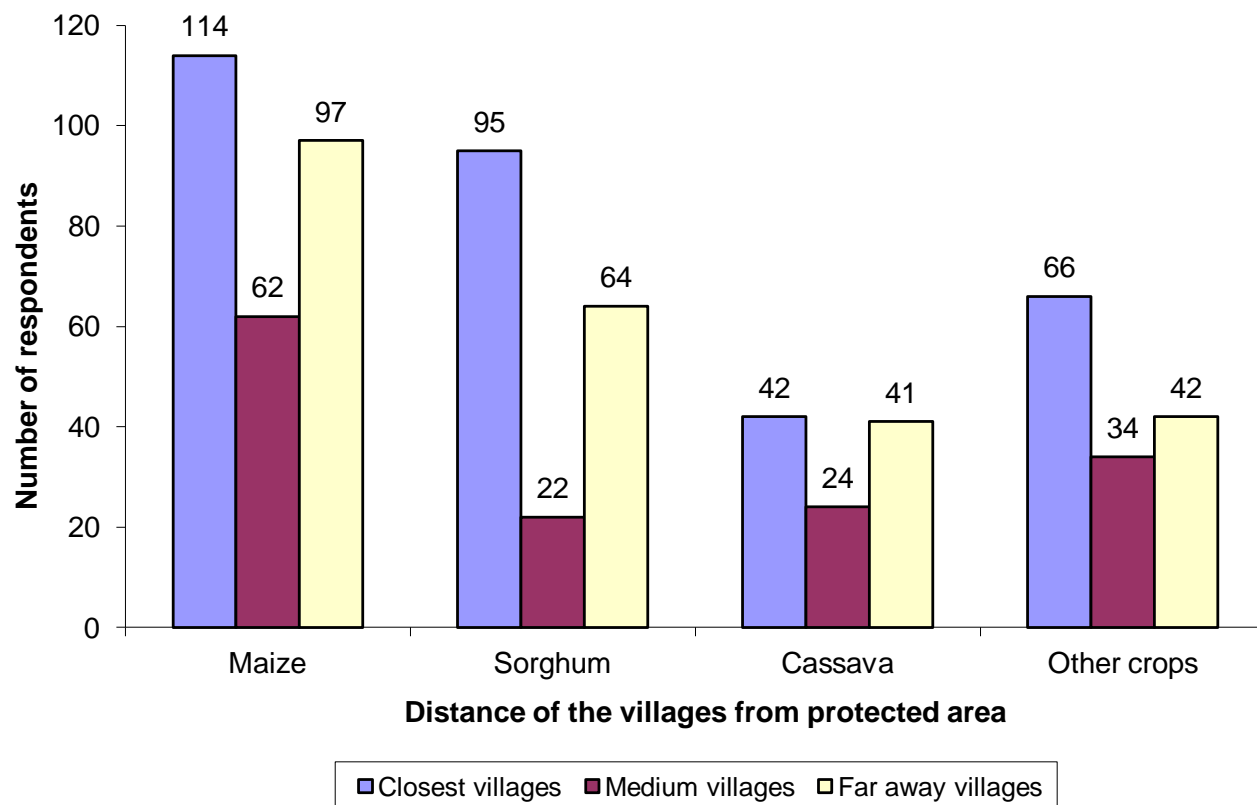


Figure 3. Wild animals involved in crop raiding at different distances from the Serengeti National Park (other wild animals include rodents, squirrels, bushpigs, warthogs and porcupines).



**Figure 4.** Number of respondents who reported different types of crops damaged by wild animals at different distances from the park (other crops include potatoes, finger millet, groundnuts and beans).

**Table 1.** Stage of crop growth when damaged.

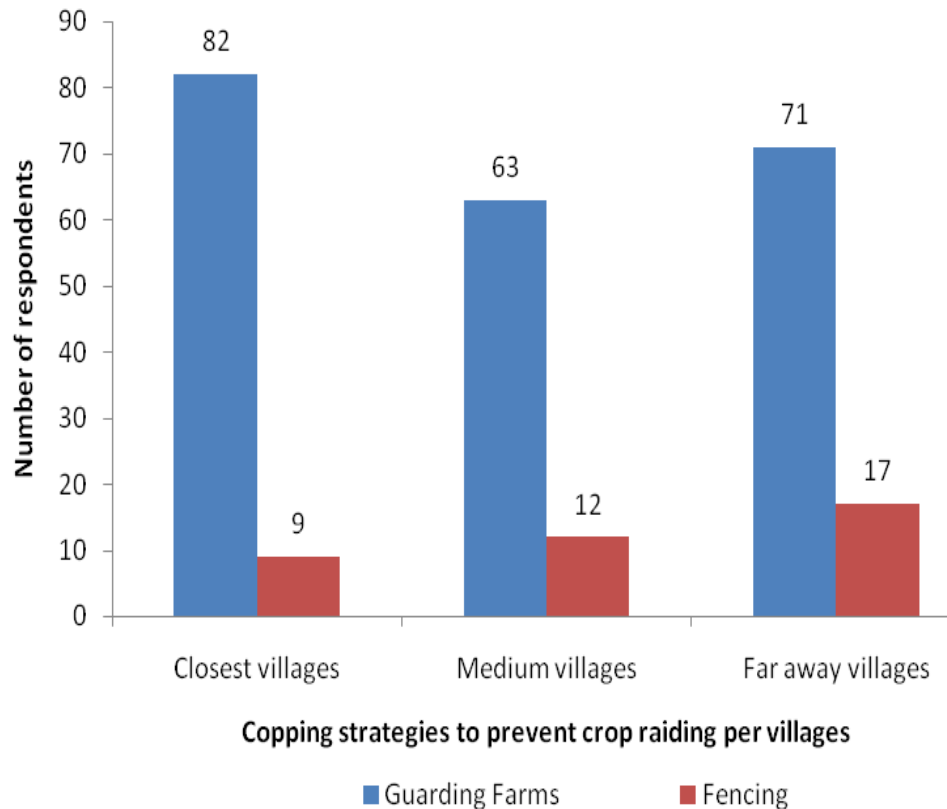
Village	Stages of crop growth					Total
		Matured	Flowering	Growth	Seedling	
Closest villages	N	33	33	16	16	98
	%	33.7	33.7	16.3	16.3	100
Medium villages	N	43	6	5	4	58
	%	74.1	10.3	8.6	6.9	100
Far away villages	N	26	21	6	4	57
	%	45.5	36.8	10.5	7.1	100

213), followed by the flowering season (28.2%, n = 213), the growth season (12.7%, n = 213) and the seedling stage season (11.3%, n = 213).

#### Measures taken by local communities for deterring crop raiders

Methods used by local communities to protect their farms from destruction by wild animals differed significantly by

the distance of the village from the protected area (Pearson Chi-square:  $\chi^2 = 13.4$  df = 6, n = 255, P = 0.037, Figure 5). The most commonly used crop protection strategy was constant guarding of the farm throughout the cropping season. Farmers reported guarding their farm throughout the day and night by patrolling their fields, actively chasing the wild animals away from the farms using dogs and building watch-out huts on the farms (85.1%, n = 255). Additionally, farmers



**Figure 5.** Number of respondents who reported different coping strategies to prevent crop raiding.

reported guarding their farms by making noise through shouting, beating drums, hunting and using firing-flashes to scare the wild animals. Moreover, respondents reported fencing their farms using thorn twigs, oily rugs and brightly coloured rugs (14.9%,  $n = 255$ ).

### Economic loss due to crop damage

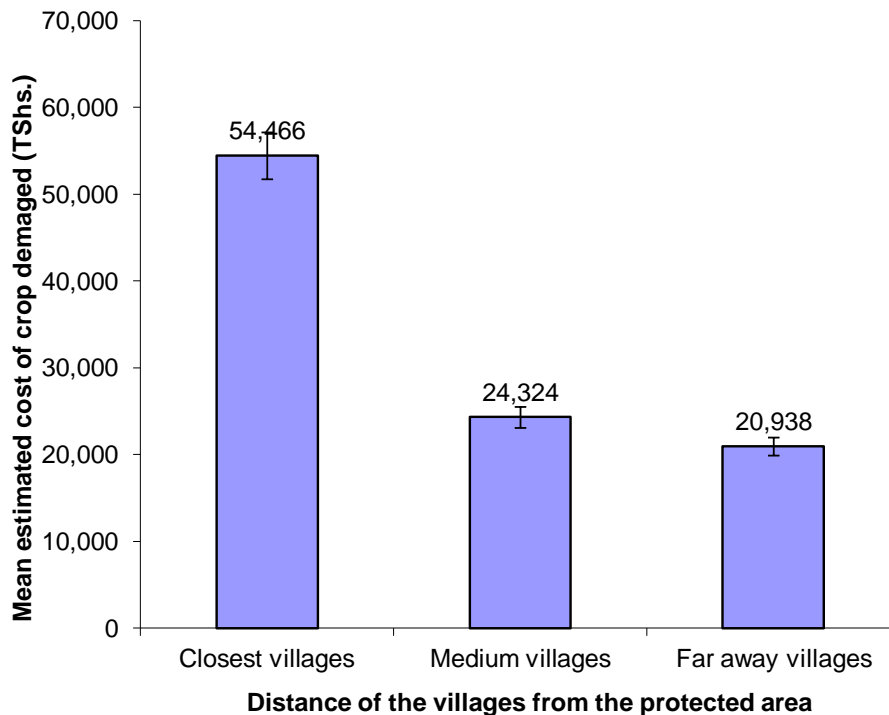
Respondents were asked to produce an estimate of the total economic losses resulting from crop damage caused by wild animals on a per household basis. The reported estimated costs differed significantly between the villages, being highest in villages close to protected areas (Pearson Chi-square:  $\chi^2 = 46.9$   $df = 10$ ,  $n = 240$ ,  $P < 0.001$ , Figure 6). The mean loss estimated in the surveyed villages was Tanzanian Shillings TSh. 34,093 ( $\pm SD = 1,224.10$ ) per household per season (equivalent to US\$ 22). This loss equated to an average loss of 16.7% of the total household income resulting from crop harvest per annum. The villages located closest to the protected areas reported the highest mean percentage loss in the total household annual crop harvest income (24.9%), which equates to a cost of TSh. 54,466 ( $\pm SD = 2,017.26$ ) (equivalent to US\$ 35) per household per season. The villages located far away from the protected area reported the lowest mean percentage loss in the

total household annual crop harvest income (11.0%), while villages in between reported a mean estimated loss of TSh 20,938 ( $\pm SD = 565.90$ ) (equivalent to US\$ 13.5) per household per season.

## DISCUSSION

### Crop raiding by wild animals with respect to distance from the park boundary

The results of this study suggest that the distance of a farm from the protected area is an important factor in determining the extent of crop raiding by wild animals. In addition, our results show that the villages closest to the protected area experience much higher frequencies of crop damage as well as higher costs of crop damage relative to villages located farther away. This result is contrary to our hypothesis that the amount of crop damage by wild animals per household per year is similar in villages adjacent to Serengeti National Park and in villages farther away from the park. The most serious damage was caused by wildlife from the park, especially elephants. However, baboons were reported to cause more crop damage in the villages most distant from the park. This is because elephants cannot move far away



**Figure 6.** Estimated average cost of damaged crops per household (1 US\$  $\approx$  1550 TShs).

from the protected areas while other raider species in habitats near these far villages cannot move back to the park because the distance they have to move back to SNP is too long. Baboons are able to thrive in human-dominated habitats, provided there are some kopjes, hills and bushes in the village lands to serve as hiding places. Some of the farthest villages surveyed were near Lake Victoria, where some forest fragments still serve as primate habitat (Hill, 2000; Gillingham and Lee, 2003; Ole Meing'ataki, 2005; Ntalwila, 2007).

### Wild animals involved in crop raiding

Different wild animals were involved in crop raiding. Primates were the most destructive wild animal in the surveyed villages at middle and far distances from the park, followed by elephants, which were destructive in the villages located adjacent to protected areas. Elephants have been reported to be the most damaging animals elsewhere in Tanzania (Ntalwila et al., 2003; Kaswamila, 2007). Moreover, African elephants, whose populations expanded rapidly following the ban of ivory trade, are presently becoming a large problem in the crop production economy, especially in villages adjacent to SNP (Ntalwila et al., 2003; Kaswamila, 2007; Malugu and Hoare, 2007; Malugu, 2010). In agreement with previous studies, the results of this study indicate that elephants

and primates are the animals most destructive to crop production. However, the ranking of the problem differs from many previous studies, which rank elephants as the most destructive (Kaswamila, 2007; Malugu and Hoare, 2007; Malugu, 2010). This may be because previous studies only concentrated on villages that were close to the park boundaries; the current study was conducted along a distance gradient up to 80 km away from the park. Sampling villages along such a gradient of distance is important in order to analyse the level of conflict and the animals involved. It is important for conservationists to focus on all rural regions, not only on areas close to protected areas, if they intend to better understand and solve the crop raiding problem. Also, this observation might be attributed to the fact that elephants cannot move far away from the protected areas, while baboons thrive in human dominated habitats as long as there are kopjes, hills and bushes in the village lands. Similar findings have been reported elsewhere (Ntalwila, 2007; Sarker and Røskaft, 2011).

Maize was the most preferred crop and thus the most damaged, followed by sorghum. This observation agrees with a report by Malugu and Hoare (2007) from similar locations. In our study, 38.8% of respondents indicated that maize was the most important crop, while 25.7% indicated sorghum. In contrast, Malugu and Hoare (2007) ranked sorghum first (20.8%) and maize second (18.9%). The fact that the two types of crops were mentioned and



respondents were able to rank them suggests that maize and sorghum are the major staple food for local communities in the area and are thus widely cultivated. Respondents in this study reported that crop-raiding peaked during harvest time in the wet season when crops were mature, followed by during flowering, as previously reported (Parker and Osborn, 2001; Malima et al., 2005; Jackson et al., 2008; Gunn, 2009; Malugu, 2010). This may be due to increased nutritional benefit from mature crops.

### Measures taken by local communities for deterring crop raiders

To protect crop fields from wild animals, local communities around protected areas use different strategies. These strategies included guarding the farm during the day and night, making noises to scare wild animals, and fencing farms (Hill, 2000; Kagoro-Rugunda, 2004; Fungo, 2011; Malugu, 2010). Local communities in the study area developed and adopted different strategies to protect their farms because they realized that no single approach was efficient enough to deter the crop raiders. Karidozo and Osborn (2007) also found that a combination of crop protective methods would better protect the crop from wild animals and aid in conserving the animals.

However, the selection of available methods of farm protection depends on the species of animal that must be dealt with. For example, for deterring large animals such as elephants, guns may be fired. According to Fungo (2011), selection of the optimal method depends on the crop being grown; guard labour availability and vulnerability of the crop to raiders.

### Economic losses caused by crop damage

Crop raiding by wild animals caused a significant economic loss in the local communities surrounding protected areas. The villages located closest to the protected areas reported the highest mean percentage loss per household per season, followed by medium villages and was reported lowest in villages located far away from the protected area. This observation might be contributed to the fact that in the closest villages, large animals such as elephants were also involved in crop damages which causes big losses as compared to baboons that were mostly reported to cause crop damages in further away villages. We found that the total estimated mean losses in the villages surveyed were highly variable; however, the mean was 16.7%. The mean percentage crop loss was higher as compared to that reported in Serengeti District (11%) (Kaswamila, 2007). This indicates the magnitude of the economic losses due to crop raiding in the local communities of the Serengeti ecosystem.

### Recommendations

We recommend further studies on the crop yield gap resulting from crop raiding by wild animals. Second, because primates were reported to be the most destructive wild animal in the surveyed villages, we recommend further studies on human-primate conflict in communities around SNP and other protected areas.

Third, in order to prevent the movement of more people closer to the park, awareness creation on the losses that the community may incur for being closer to the park boundary is highly recommended. Lastly, for effective protection of crop farms from wild animals, we recommend that local communities adopt a combination of methods to deter crop-raiding wild animals from their farms for examples, Chill and bee fences (Fungo, 2011; Kabepole, 2011; Malugu et al., 2011), guarding and making noises (Hill, 2000; Malugu, 2010) as suggested by Karidozo and Osborn (2007).

### Conflict of Interests

The author(s) have not declared any conflict of interests.

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