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Sustainability of bushmeat and sardine industry based on socio-ecological considerations at Serengeti National Park and Lake Victoria, Tanzania

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Abstract

Protected areas and lakes are important for biodiversity conservation and sustainable development strategies. The two generate significant economic and food resources for local communities adjacent to these resources. This study was conducted in the north-western part of the Serengeti ecosystem from September to November 2016 (Dry season) and from March to May 2017 (wet season). The prices of bushmeat and sardines were directly measured from the dealers in each sampled village. Weights were measured using an electronic kitchen scale (CAMRY Model: EK 3131). Statistical analyses were performed using Statistical Package for Social Sciences (SPSS, 22 versions for windows). Mean prices of sundried bushmeat and sardines increased along the gradient of distance from the park and the lake, respectively. Bushmeat availability was higher during the dry season in all sampled villages. Wet season supply was limited only to Robanda and Rwamkoma villages. Prices of sardines did not vary with season. High supply of bushmeat during dry season was most likely due to the influx of migratory herbivores. Generally, socio-ecological variables that explain the sustenance of illegal bushmeat hunting and/or selling were loss of livestock, unemployment, elimination of problem animals and enjoying the business. Other variables included inherited the business and lack of benefit sharing between the park authority and the communities. Resident herbivores might be the target of illegal bushmeat hunters during the wet season, hence may need special conservation attention.

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Introduction

Globally, protected areas and lakes are important areas for biodiversity conservation and are the cornerstone of sustainable development strategies (Cowlishaw and Dunbar, 2000; UNEP, 2008). Apart from their environmental benefits, they can also generate significant economic and food resources for local communities (Apaza *et al.,* 2002; Nyahongo *et al.,* 2009; Nielsen *et al.,* 2017). Bushmeat and fish resources are important sources of meat protein for communities adjacent to protected areas and lake zones, respectively (Mbete *et al.,* 2011; Nyahongo *et al.,* 2009). Wildlife provides up to 30 per cent of the protein requirements of the rural population in Sub-Sahara Africa (Nasi *et al.,* 2008; Nielsen *et al.,* 2017). In Western Serengeti, Tanzania, bushmeat hunting, which involves resident and migratory herbivores, is an important economic activity of adjacent communities (Mfunda and Røskaft, 2010). The resident herbivores include giraffe *Giraffa camelopardalis*, buffalo *Syncerus caffer,* topi *Damaliscus korrigum,* warthog *Phacochoerus africanus* and impala *Aepyceros melampus*. Migratory herbivores include wildebeest *Connochaetes taurinus,* zebra *Equus burchellii* and Thomson gazelle *Eudorcas thomsonii*. The majority of communities are subsistence farmers who depend on bushmeat and fish as sources of protein (Loibooki *et al.,* 2002; Nyahongo *et al.,* 2009; Mfunda and Røskaft, 2010). The location of villages relative to protected areas influences bushmeat consumption, whereby consumption rates are higher in villages close to the protected areas (Brashares *et al.,* 2011; Ndibalema and Songorwa, 2008; Nyahongo *et al.,* 2009). Bushmeat preference may be influenced by taste (Nyahongo *et al.,* 2009; Mbete *et al.,* 2011) and tradition (cultural values) (Fa *et al.,* 2002; Kaltenborn *et al.*, 2005; Mbete *et al.,* 2011).

Fish are also vital sources of animal protein in rural areas (de Merode *et al.,* 2004; Geheb *et al.,* 2008). Lake Victoria is the major source of fish for communities adjacent to the Serengeti ecosystem. However, commercial fishing in Lake Victoria to supply the global market has reduced fish availability to a large extent, thus causing food scarcity to local people around the lake (Balirwa 2007; Geheb *et al.,* 2008; Knapp, 2010). As such, sardine *Rastrineobola argentea* (locally known as dagaa) is the only fish species that are commonly available for all communities during dry and rainy seasons. Availability of sardine to local markets may be due to their sizes, which make it easier to sun-dry to increase the shelf life, as opposed to large fishes like Nile tilapia *Oreochromis niloticus* and Nile perch *Lates niloticus,* which normally require a cold chain, like refrigerators, to reach the potential consumers. Besides, sardines, unlike other large fish, are not commercially exported to the European markets; hence, sardines are more available for local markets. Pollution, environmental degradation, depredation of other fish species by introduced Nile perch might have contributed to the reduced large and medium fish availability in the Lake Victoria (Balirwa, 2007). As a result, the exploitation of bushmeat, to meet the low supply of meat protein to communities around the Serengeti-Mara ecosystem, might increase threats to the future conservation of wildlife.

A linkage between bushmeat, livestock and fish utilisation in sub-Saharan Africa and Latin America has been well documented (Wilkie and Godoy, 2001; Apaza *et al.*, 2002; Brashares *et al.*, 2004; Nasi *et al.*, 2008; Wilkie *et al.*, 2005; Nyahongo *et al.*, 2009). However, in the Serengeti-Mara ecosystem, the variation of prices of bushmeat and fish and the way consumers respond to such variations along the gradient of distance from the park boundary and Lake Victoria has received little attention. Likewise, the opinions of communities involved directly in bushmeat business (illegal hunting and selling of bushmeat), as to why they are engaged in the business, has hardly been documented, probably because the issue is sensitive to communities. The present study aimed to investigate how the prices of bushmeat and that of sardines vary along the gradient of distance from the park and the lake, respectively. Among other important factors (taste, culture, resource availability, problem animals – hereafter referred to wild animals that destroy crops, destroy

water sources in village areas, attack and kill livestock and/or injure/kill people) influencing the perpetuation of illegal bushmeat business among communities located in various places from the park. In addition, the current study aimed to explore the opinions of communities who were engaged directly in illegal bushmeat business to understand in detail the reasons for them conducting such illegal activities despite the strict law enforcement. Understanding the price variations along the gradient of distance from the sources as well as the opinions of illegal bushmeat hunters and sellers may help to predict the demand and supply ratios and the business sustainability and direction of such supply of the two resources spatially. This might have an implication for the future conservation of bushmeat species in the Greater Serengeti-Mara Ecosystem (GSME).

Material and methods

Study area

This study was conducted in the north-western part of Serengeti National Park, Tanzania (Fig. 1), from September-November 2016 (Dry season) and February-May 2017 (wet season). Villages to sample were systematically selected based on distance from the park boundary, whereas the first village (Robanda) was located within five kilometres from the park boundary and the second was located at least 45km from the park boundary (Rwamkoma village). The third sampling area was conducted in Rorya District (80km from the park boundary) where several villages were sampled due to a low number of people dealing with bushmeat business in each village. In addition, several villages were sampled in Rorya District in order to take advantage of cross border bushmeat business. The villages included in this study were Kowak, Osiri, Ratia and Tatwe (Fig. 1). It was important to survey the villages in Rorya District, especially those close to Tanzania-Kenya border, to investigate the trend of illegal export of bushmeat to Kenya from Tanzania's side of GSME. It was assumed that bushmeat dealers from Serengeti (Tanzania's side) would export illegally bushmeat to Kenya to obtain high profits because, in 2017, the Kenyan's currency was almost 20 times higher than the currency in Tanzania.

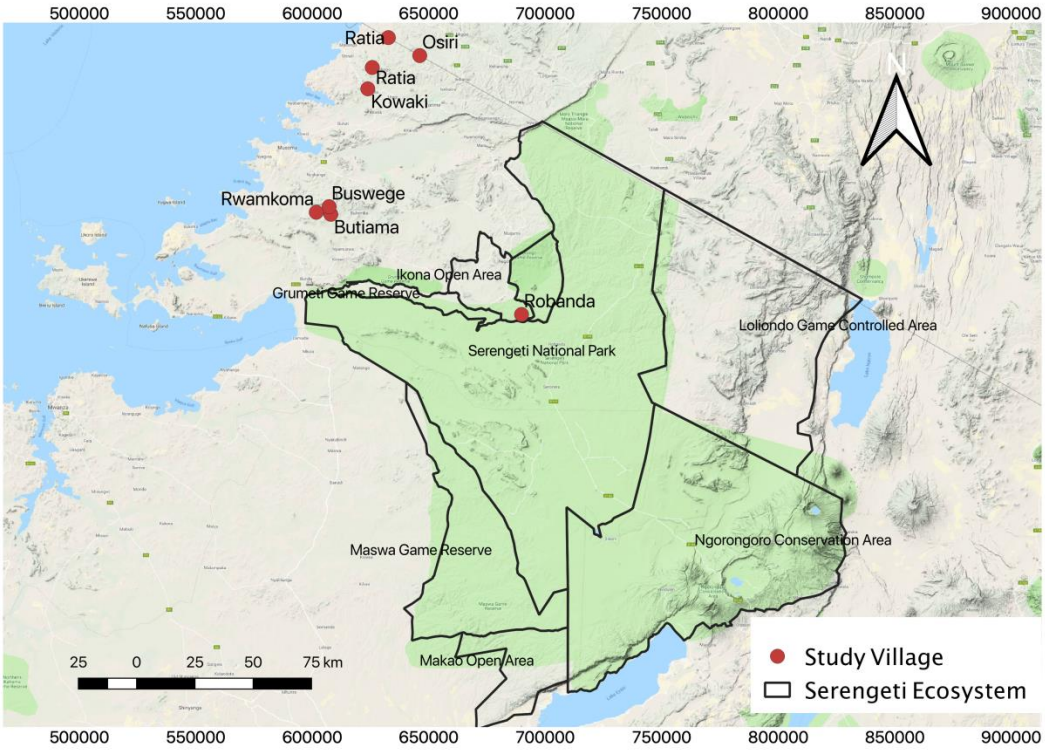

Fig. 1. Map of the study location showing Serengeti National Park, Grumeti and Ikorongo Game Reserves, Lake Victoria and surveyed villages.

The GSME is best known as the ecosystem with the greatest concentration of large mammals in the world, ranging from grazers and browsers to carnivores (UNEP, 2008). A growing human population whose major economic activities are subsistence farming and livestock rearing densely settles the western area of GSME. Agriculture is the main source of income, but many people are attracted to the wildlife and the tourism employment opportunities of the park and land for agriculture (UNEP, 2008). Illegal bushmeat hunting in the area is widespread (Loibooki *et al.,* 2002; Mfunda and Røskaft, 2010). Bushmeat is commonly sundried and used for home consumption and for sale to generate income (Loibooki *et al.,* 2002; Mwakatobe *et al.,* 2012).

Data collection

The sampling design adopted was a snowballing technique. This sampling technique is applied when it is difficult to access subjects with the target characteristics (Naderifar *et al.,* 2017). In this method, the existing study subjects recruit future subjects among their acquaintances. Sampling continues until data saturation.

In each village, one or more assistants were recruited in the first place. The assistants were trusted and respected people in the village. In some villages, the assistants were the bushmeat dealers themselves or those who were dealing with bushmeat business in the past. Before being appointed to assist the project, he or she was requested to confirm whether he or she knows any illegal bushmeat hunters in the area and if they would be ready to identify the bushmeat dealers for the current study. We ensured them of confidentiality and that we were not interested to report who sells meat but rather we were interested to understand the business chain from the source to the final consumption unit and how the business is organized throughout the year.

Once the bushmeat dealer was identified, we visited the household and carefully asked him or her to allow us to weigh some pieces of meat they own for only research purpose. In most cases, the bushmeat dealers did not cooperate. However, when the bushmeat dealer agreed to cooperate with researchers, we introduced ourselves and the aim of our study. When allowed to weigh bushmeat, we used an electronic kitchen scale (CAMRY Model: EK 3131) to measure the weight of each piece of meat in gram. After weighing the meat, we recorded the prices of each meat sold. Before leaving the household, the respondent was requested to explain as to why she or he was engaging in such business while knowing its consequences when caught. Also, they were requested to explain if they had been caught before and how many times. All interviews were recorded using an Olympus Digital Voice Recorder (WS-650S). The respondents were assured that the discussion would be recorded for the purpose of scientific analysis and not for any other purpose and soon after analysis, we would delete the voices. Their responses were later compared to a pre-prepared checklist with the following variables: *I am doing this business because:*

i) We do not gain any benefit from wildlife authorities.
ii) I am a widow and have children to feed and care.
iii) There is market demand hence I am just supplying the commodity.
iv) I need money to pay for health cost.
v) I want to revenge because wildlife destroyed my crops, killed my livestock, and injured/killed my relative.
vi) I lost all my livestock to wildlife/or theft hence do not have any source of income.
vii) I need money to pay the school fee for my children.
Viii) I am not employed hence this business is my source of income.
ix) Source of meat protein – food.
x) I just like this business.
xi) When you engage in illegal bushmeat hunting/or selling you are respected by the community.
xii) We lost our fertile land to wildlife/or to governmental projects.
xiii) We hunt to reduce the numbers of problem animals.
xiv) I inherited this business from my parents.

The same household was visited during the dry and rainy season. In the same villages, researchers visited the local market to determine the prices of sardines per unit volume. This was later measured to obtain the weight in gram. Since sardine business is legal, no much effort was deployed to convince the sellers

about the aim of this project. Almost 100% of sardine sellers cooperated. We recorded the weight and prices of sardines at each market place. We also recorded the GPS position for subsequent calculation of the distance from the lake, which later was deleted after the spatial analysis.

Data analysis

Statistical tests were performed using Statistical Package for Social Sciences (SPSS, 22 versions for windows). Descriptive statistics were used to calculate the means and standard errors of the mean. Results were presented as Mean ± Standard Error. Pearson Correlation was used to test for association between prices of sundried bushmeat and distance from the park as well as the weight of pieces of meat sold at various markets along the gradient of distance. The same statistical technique was used to explain the existing association between the prices and weights of sardines along the gradient of distance from Lake Victoria. Multinomial regression analysis was used to predict the influence of independent variables (see data collection section) on the dependent variable ("why do you illegally hunt wildlife or sell bushmeat?"). For all comparisons among test categories, $p > 0.05$ was considered insignificant.

Results

An overview

The prices of pieces of bush meat in different villages located in Rorya District were the same, as such all data were pooled and we used one village; Kowak as a focal village for distance calculation. At Rwamkoma, we also surveyed other two villages; Butiama and Busegwe but used Rwamkoma village as a representative for distance calculation (Fig. 1). Majority of bushmeat dealers declined to cooperate. For instance, at Robanda village, of 316 identified potential bushmeat hunters and/or dealers, only 50 (15.8%) respondents cooperated. At Rwamkoma, the respondents identified through snowballing to be selling and /or participating in bushmeat hunting were 112. However, only 46 (41.1%) cooperated while at Rorya District, 79 individuals were identified to be participating in bushmeat business and 57 (72.2%) agreed to be interviewed and allowed researchers to weigh the bushmeat they were selling. All bushmeat hunters and/or sellers had been arrested at least once. Those who had been arrested only once were 56.2% (n = 153), while 15.7% (n = 153) were arrested twice and 8.2% (n = 153) were arrested three times. The remaining had been arrested more than three times (19.9%, n = 153). When asked about the penalties they received when arrested, most of them claimed that they just bribed those who arrested them (77.5%, n = 153), some donated pieces of meat to law enforcers who catch them (12.7%) while a few paid the government set penalties in the court of law (9.8%, n = 153).

One business woman from Kowak village said, "When you are dealing with illegal business like this, you must be smart and generous. First, you must make sure that you do not cause any problem with your neighbours, villagers and/or religious leaders. Sometimes you need to give them some meat to cook for their families free of charge. If you do that, they will protect you and will inform you of any arrest plan in the future, if they come to know or hear. In some cases, we need the neighbour's stores to keep some of our illegal bushmeat because sometimes you are just ambushed and if some meats are stored in a different place, you save some of it. If you are quarrelsome, I tell you, do not ever try this business, you will be caught within a day of first consignment. Your enemy will just call to inform the authority, especially during these days where everyone own a mobile phone."Another bushmeat dealer from Osiri village claimed that to be able to run the business smoothly, you must set aside some funds for bribing whomever come to arrest you. She said, "My business capital is about Tsh. 1,600,000 (USD 762), which usually brings a profit of about Tsh. 400,000 (USD 190) per trip and I can make three trips each month during dry season. Sometimes we are lucky; they (she did not want to mention the identity of those she call 'they') just bring meat here in the village. When I get such profit, I set aside Tsh 100,000 (USD 48) for security purposes, and I am happy with that as I consider that as a cost of production as any business entity would incur.

Sometimes, 'they' would demand more and I have to pay. If I do not they take all meat and take you to the court of law. This is why our capital never grows."

Amount of variations in prices of sun-dried bushmeat and sardine along the gradient of distance from GSME and from Lake Victoria

Regardless of the influence of season, mean prices of 1kg of sundried bushmeat varied along the gradient of distance from GSME boundary. The prices of any given weight of sardine also vary along the gradient of distance from Lake Victoria. Overall calculated mean price of 1kg of bushmeat was highest at Kowak village, the most distant village from the park but was cheapest at Robanda, the closest village. For sardine, the highest prices were calculated at Robanda village (i.e. 100km from the lake) followed by Kowak (60km from the lake) and became relatively cheaper at Rwamkoma (30km from the lake) (Table 1). When data were treated on dry-wet season basis, mean bushmeat prices perkg in all sampling villages were higher during the wet season than during the dry season (Robanda: $t = -9.316$, $df = 98$, $p < 0.001$; Rwamkoma: $t = -3.579$, $df = 90$, $p < 0.001$, Kowak: $t = -5.459$, $df = 112$, $p < 0.001$). The mean prices of 1kg of sardine did not vary with season (Robanda: $t = 1.123$, $df = 98$, $p = 0.264$; Rwamkoma: $t = -1.770$, $df = 90$, $p = 0.860$; Kowak: $t = -1.235$, $df = 112$, $p = 0.219$) (Table 1). The calculated mean rate of increase in price of 1kg of bushmeat perkm along the gradient of distance from the boundary of GSME was Tsh 216.1 ± 6.6 (US$ 0.103). This suggests an increase in price of the item along the gradient of distance from the park boundary (Pearson Correlation, $r = 0.741$, $n = 306$, $p < 0.001$). The mean rate of increase of price of 1kg of sardine from the lake was Tsh. 86.8 ± 1.8 perkg perkm. Among the three locations, the distribution of bushmeat prices differed significantly (One-way ANOVA, $F_{1,2} = 231.861$, $df = 305$, $p < 0.001$). A Post Hoc Test was performed to confirm the existing differences between villages using Bonferroni corrections; however, all differences were significant ($p \leq 0.003$). Likewise, the distribution of prices of sardines among the three villages differed significantly (One-way ANOVA, $F_{1,2} = 148.9$, $df = 305$, $p < 0.0001$). However, a Post Hoc Test confirmed insignificant difference in the prices of equal weight of sardines between Kowak (60km) and Robanda (100km) ($p = 0.944$) but was significant between Rwamkoma and Kowak ($p < 0.0001$); and also Rwamkoma and Robanda ($p < 0.0001$).

Table 1. Variation of prices (in US$) bushmeat and sardine along the gradient of distance from GSME and Lake Victoria.

Villages	Average air distance (Km) from GSME	Average air distance (Km) from Lake Victoria	Mean price (US$) of 1kg of Bushmeat			Mean price (US$) of 1kg of sardine		
			Overall Mean ± SE	Dry season Mean ± SE	Wet season Mean ± SE	Overall Mean ± SE	Dry season Mean ± SE	Wet season Mean ± SE
Robanda	5	100	3.4 ± 0.1 n = 100	2.8 ± 0.1 n = 50	4.0 ± 0.9 n = 50	4.9 ± 0.1 n = 100	5.0 ± 0.1 n = 50	4.9 ± 0.1 n = 50
Rwamkoma	40	30	9.8 ± 0.4 n = 92	8.0 ± 0.2 n = 46	11.6 ± 0.6 n = 46	2.6 ± 0.1 n = 92	2.5 ± 0.2 n = 46	2.6 ± 0.1 n = 46
Kowak	80	60	11.1 ± 0.3 n = 114	9.7 ± 0.4 n = 57	12.5 ± 0.3 n = 57	4.7 ± 0.1 n = 114	4.6 ± 0.2 n = 57	4.9 ± 0.1 n = 57

NB: Exchange rate for Tanzanian shillings to US dollar was TSh 2100 per dollar in May 2017.

Amount of variations in predicting the sustainability of illegal bushmeat business

Respondents were asked a general question, "Why do you illegally hunt or sell bushmeat? Their opinions recorded and subsequently compared to prepared checklist containing possible reasons for undertaking illegal bushmeat activities. The generated information were analysed to determine which variables were significant, using a multinomial regression analysis. Regardless of distance from the park boundary, the model revealed that the variables "loss of livestock, liking the business and lack of benefit obtained from park authority" were the important variables that explained amount of variations among the respondents interviewed (Table 2).

Table 2. Overall Multinomial Regression Model result showing significant independent variables that explain amount of variations on the sustainability of illegal bushmeat hunting and/or selling along the gradient of distance from the park boundary. Posed question was "Why do you illegally hunt and/or sell the bushmeat?".

Villages	Variables	B	S.E	Wald	Df	Sig.	Exp(B)
	Lost livestock	1.956	.429	20.819	1	.000	7.070
	Lost land	-.053	.375	.020	1	.888	.948
	Unemployed	-.995	.535	3.454	1	.063	.370
	Widow	-.221	.343	.416	1	.519	.801
	School fees	.411	.346	1.409	1	.235	1.508
	Health cost	.503	.365	1.897	1	.168	1.653
	Food	.251	.358	.492	1	.483	1.286
	Problem animal	-.827	.356	5.395	1	.020	.437
	Like business	-.868	.349	6.163	1	.013	.420
	Inherited business	-1.552	.379	16.739	1	.000	.212
	Social status]	.325	.442	.539	1	.463	1.383
	Market demand	.251	.382	.433	1	.511	1.285
	Revenge	-.089	.374	.056	1	.812	.915
	No benefit	-1.374	.539	6.500	1	.011	.253
	Intercept	-1.580	.479	10.888	1	.001	
	Lost livestock	-1.600	.476	11.298	1	.001	.202
	Lost land	.515	.422	1.493	1	.222	1.674
	Unemployed	2.980	.508	34.406	1	.000	19.684
	Widow	1.296	.425	9.292	1	.002	3.655
	School fees	.149	.392	.144	1	.704	1.161
	Health cost	-.338	.387	.763	1	.382	.713
Rwamkoma	Food	-.649	.426	2.315	1	.128	.523
	Problem animal	-.479	.455	1.109	1	.292	.619
	Like business	-1.640	.478	11.755	1	.001	.194
	Inherited business	.688	.479	2.062	1	.151	1.989
	Social status	.887	.477	3.465	1	.063	2.428
	Market demand	-.656	.448	2.147	1	.143	.519
	Revenge	.993	.418	5.641	1	.018	2.699
	No benefit	2.517	.569	19.572	1	.000	12.389
	Intercept	-.840	.419	4.017	1	.045	
	Lost livestock	-1.956	.429	20.819	1	.000	.141
	Lost land	.053	.375	.020	1	.888	1.054
	Unemployed	.995	.535	3.454	1	.063	2.705
	Widow	.221	.343	.416	1	.519	1.248
	School fees	-.411	.346	1.409	1	.235	.663
	Health cost	-.503	.365	1.897	1	.168	.605
Kowak	Food	-.251	.358	.492	1	.483	.778
	Problem animal	.827	.356	5.395	1	.482	.775
	Like business]	.868	.349	6.163	1	.013	2.381
	Inherited business	1.552	.379	16.739	1	.000	4.719
	Social status]	-.325	.442	.539	1	.463	.723
	Market demand	-.251	.382	.433	1	.511	.778
	Revenge	.089	.374	.056	1	.812	1.093
	No benefit	1.374	.539	6.500	1	.011	3.953

Discussion

The information that is communicated through this paper was derived from illegal bushmeat dealers. Thus, we believe that the reasons that were portrayed as the causes of such illegal bushmeat business organization were true, although they might have exaggerated some issues related to problem animals and lack of cooperation with wildlife authorities to appeal to the rest of the world of their living strategies adjacent to protected areas.

Cooperation between researchers and illegal bushmeat dealers were made possible after assuring the respondents of confidentiality of the information they were generating. However, most people from Robanda village (the closest village to park boundary) did not like to cooperate with researchers probably due to sensitivity nature of this study. This finding supports Nuno *et al.* (2014) report, which suggested that only 18% of households interviewed admitted to involve in illegal bushmeat hunting in Serengeti.

Majority of respondents who agreed to participate in interview sessions were sensitive, suspicious and restless. In most cases, they would be roaming around the room, watching outside through the windows or doors, as if we were expecting park rangers or police officers in the house to arrest them. In some cases, the respondents were asking the interviewers to complete such session quickly. In Tatwe Village (Rorya District), a husband blamed his wife openly that she had invited a problem in the house when he came in and found strangers interviewing the wife while also weighing same pieces of bushmeat they illegally own. He said, "*We are finished, our capital is gone, we are going to jail all because of you woman*."We had to stop our interview to ensure him that we are not prosecutors or agents. Suspiciously, he allowed his wife to continue with the interview. In most cases, the respondents did not want to identify another bushmeat hunter or a seller. However, after insisting that it was important just to nominate at least one person, they would say, "*Please do not tell him/her that I am the one who nominated him/her whenever you meet them.*" This suggests sensitivity of the business to the community who consider it as a primary source of food protein and income. It might be possible for the communities to make an informal agreement among themselves to hide the business information to any stranger visiting the villages. This observation supports the idea of the illegal behaviour of people. Gavin *et al.* (2010) suggest that true extent of illegal activities among people is hard to quantify due to fear of prosecution and the cryptic nature of the behaviour. Moreover, Mateo-Tomás *et al.* (2012) observe that illegal behaviour is a frequent source of uncertainty that affects management decisions and compromises evaluations of conservation interventions.

Distance from the park is an important parameter to predict the prices of bushmeat as it influence demand and supply for the commodity. The mean prices increase with distance from the park (the source). At the area, supply is high, hence low demand and therefore low price. At distant villages, where supply is low due to transportation and safety costs, the demand might have been high, which also might have influenced the price in a positive direction, when all other factors remain constant. This observation suggests that illegal bushmeat business operates in a purely socio-economic terms and follow the law of demand and supply as described by Gujarati (2004). Similar observation and explanation is true for sardine. However, the observed small price differences between 60km and 100km from Lake Victoria might be due to the fact that most people at Kowak village (60km) consume sardine largely (hence high demand that influence the price) compared to Robanda which is closer to the park (high supply of cheap alternative protein source –bushmeat. Thus the determinant of the prices of sardine at Kowak and Robanda is the amount of alternative protein sources available in respective area that compete with sardine and not purely due to the cost of transport. However, the price of sardine at Rwamkoma which is only 30km from the lake had been relatively cheaper, which suggests the influence of distance and availability of other alternative protein sources such as livestock meat and bushmeat.

Season of a year has an influence on supply of bushmeat around the GSME. In northwestern Serengeti where we conducted the current study, the influx of migratory herbivores into villages takes place between June and October each year. This period is dry, hence is the time when most illegal hunting using set snares and pitfall traps take place (Nyahongo *et al.,* 2009; Mwakatobe *et al.,* 2012). Wet season (November-May) migratory herbivores move farther southeast (southern plain) and/or southwest (western corridor), where most illegal bushmeat hunters from the study area cannot reach. In addition, during the rainy season, the big rivers within the park become natural barriers, as they become over flooded, hence dangerous to cross, thus would limit the access to profitable bushmeat resources. Nyahongo *et al.* (2009) reported similar observation. Moreover, one adult male from Robanda confirms this observation as he says, "*During the rainy season, we usually engage in fishing along the rivers using hooks and bait or setting traps for small mammals like dik dik (Madoqua kirkii) and African hare (Lepus microtis) because other big herbivores are already moved far beyond our reach. We cannot follow them there for two reasons; firstly,*

park rangers with guns would shoot us down if encountered deep inside the park and secondly, we are wary of swollen rivers; lots of crocodile will not let us cross; crossing through the bridges are equally dangerous because rangers will spot us."

Overall, multinomial regression analysis revealed that livestock loss, liking the business and lack of benefit communities receive from the wildlife authorities were the important variables that explained amount of variation among the illegal bushmeat dealers, of which when omitted the model becomes unfit. Livestock keepers lose their livestock mostly due to diseases, theft and/or indirectly through loss of valuable grazing lands, which is converted to farms and settlements (Nyahongo and Røskaft, 2012). Livestock are the living bank for rural communities and are the direct measure of family wealth; less or lack of which suggests the level of poverty, and hence engagement on illegal bushmeat activities (Looiboki *et al.,* 2002). In Tanzania, as in other sub-Saharan Africa, poverty is a common phenomenon were most people, especially in rural areas, live in less than one U.S. Dollar per day (URT, 2012). Poor families would likely go to protected areas illegally to access natural resources for food and income. Admitting the liking the illegal bushmeat business, respondents confirm their alternative livelihood strategies (cheap source of food and income) which, is socially acceptable among the communities. One adult man from Robanda confirms this "*When I go in the park and come home with bushmeat my family are happy and friends regard me as a hero but when I go to distant village and steal heads of cattle and bring home safely, people regard me as a thief and would not be respected at all. That is because wildlife belongs to God but livestock belong to people. We always use God's things free of charge and never exhaust them."*

Respondents claimed that they participate in illegal bushmeat business because they do not benefit from wildlife despite the fact that they incur cost in terms of livestock depredation, crop damage or attack by wildlife. Wildlife authorities in Tanzania have been sharing the benefit accrued from wildlife to communities through outreach programs since 1980s following the failure of American Yellowstone Model of fences and fines (TANAPA, 1996). These programs usually target the community i.e. building hospital, schools, roads and bridges. In turn, the authorities expect communities to participate fully in conservation programs and should refrain from illegal activities such as poaching and grazing livestock inside protected areas. Contrary to the expectation of wildlife authorities, the illegal activities are still experienced in the protected areas. When, a Village Executive Officer at Robanda was requested to explain why do people engage in such ill activities despite the services they receive from Tanzania National Parks (TANAPA), he said "*Our village is rich, we have in the village account Tanzanian Shillings 300 million (USD 130,434.8), but people are poor. The only way to reduce poaching for bushmeat and trophies inside the park is through creation of stable source of income to individual people living close to park. We have been insisting to the park authority to hire people from our villages as casual labourers but they always turn our request down."*This suggests that any social service that is provided at community levels have less impact than those directed to household levels.

Along the gradient of distance from the park, socio-ecological variables that explained amount of variation among respondents were area specific. For instance at Robanda, problem animals and inheritance of the business were the addition significant variables that explained amount of variation among the respondents. It is not surprising to have problem animals like elephants destroying crops and spotted hyenas attacking livestock at night at Robanda because the village is surrounded by protected areas. In addition, it is not surprising for illegal bushmeat hunters/sellers to pass the hunting or business skills from one generation to another because the activity is socially accepted as major source of meat protein and income to household at Robanda and Kowak villages. At Rwamkoma, in addition to already discussed variables (loss of livestock, like the business and lack of benefit received from wildlife authorities), lack of

employment, being widow and killing wildlife for revenge due to crop damage or injury to people, were the significant variables that explained amount of variation among the respondents in the area. All the raised social-economic variables at Rwamkoma confirm the level of poverty at the household. As discussed earlier, poor families would go for the best alternative resource for their survival. In this case, bushmeat obtained illegally is the best alternative and affordable source of meat protein for unemployed and widow people in the communities. Killing wildlife for revenge might happen occasionally. This would only happen when wildlife transgress to village land. Generally, communities protect their properties and expect to be compensated fully when damage to any property occurs. However, for the existing compensation (consolation) scheme and the policy, that wildlife authority use does not offset the damage incurred by 100% and yet the process to confirm the damage is cumbersome (URT, 2011).

Sardine is consumed throughout the study area probably because the fish is supplied in large quantities in all villages. High supply of sardine in all local markets regardless of distance from the lake might be due to the size of fish and required storage facilities. Sardines are small and hence can dry up quickly when exposed on direct sunlight as compared to tilapia or Nile perch. When sundried, the fish can be transported to various places packed in cheaply and locally available nylon bags. In addition, low supply of large fish that are exported to European markets, overexploitation of fish resources by humans, water pollution and environmental degradation due to water hyacinth *Eichronia crassipes* (Balirwa, 2007) made sardine the most available and cheap source of protein to communities regardless of the distance from the lake. This might also increase demand for bushmeat hence increase intensity of illegal bushmeat hunting. Asking one fisherman at Tamau village of the current fishing operation and availability of fish as compared to the past years, he said, "*In the past, a fisherman and his family would not eat sardine; the fish was for people who have never seen the lake (*meaning those living far from the lake*), but since the establishment of European market for African fish, we are now fighting hard to feed our children the fish-factory-leftovers and sardines*." This narration confirms that sardine is now a primary source of fish protein to all communities regardless of the distance from the lake.

Conclusion and recommendations

The information generated from respondents who were illegal bushmeat dealers is important in predicting the sustainability of illegal bushmeat business and hence draw the mitigation strategies in GSME. We have observed that illegal bushmeat hunters who live close to protected areas are more sensitive to issues regarding illegal hunting because they understand the consequences of illegal hunting to the court of law. It is observed also that only few illegal bushmeat dealers would be ready to respond to any interview that seeks for information regarding illegal bushmeat hunting. Trust and confirmation of confidentiality of the information generated from illegal bushmeat dealers are the important pillars for the success of this kind of study.

The study concludes that the prices of a given weight of sun-dried bushmeat and sardine varied along the gradient of distance from the park boundary and the lakeshore, respectively. The prices of sun-dried bushmeat are cheapest at Robanda village, which is closer to park boundary and is most expensive at Kowak; the distant village, probably due to transportation cost, security reasons, time and the volume of bushmeat supplied. Seasons of a year influence the supply of bushmeat in the study area, whereas dry season supply is higher than the wet season due to influx of migratory herbivores to the village proximity. Socio-ecological variables that explained the sustenance of illegal bushmeat hunting and/or selling were mainly due to poverty resulting from loss of livestock, liking the business and lack of benefit sharing between wildlife authority and the household located adjacent to protected areas although some benefits are transferred to surrounding communities such as construction of schools, hospitals and roads. European markets for

large fish from Lake Victoria, overexploitation of fish resources by humans, water pollution and environmental degradation due to water hyacinth made sardine the most available and cheap source of protein to communities regardless of the distance from the lake.

We recommend the followings:

- Provision of veterinary services to reduce livestock loss due to diseases is recommended because diseases are the major source of livestock loss compared to depredation by wild carnivores or theft. The veterinary department should provide service to livestock keepers so that the challenges and loss from diseases are reduced.
- Sharing benefit accrued from tourist related business is recommended. The benefit shared should target the household where the cost related to wildlife is experienced. Wildlife authorities should target households or individuals rather than channelling the fund to community as whole.
- A special training programme for entrepreneurship for self-employment and provision of soft loan for small business to household members in order to generate income for household is recommended. This would reduce the reliance of households to bushmeat as source of income and food protein. The government and private sectors such as Franfurt Zoological Society, African Wildlife Foundation, World Wildlife Fund, Global Environmental Facility and other organization overseeing environment and conservation should fund such activities.
- Resident herbivore might be the target of illegal bushmeat hunters during the wet season and thus special conservation attention should be paid by wildlife authorities to ensure their future survival in the area.
- The wildlife authority should consider employing people from adjacent communities, especially for casual labours.

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