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Authors: Bitanyi, Stella, Nesje, Marit, Kusiluka, Lughano JM ,  
Chenyambuga, Sebastian W , and Kaltenborn, Bjørn P

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## Research Article

# Awareness and perceptions of local people about wildlife hunting in western Serengeti communities

**Stella Bitanyi<sup>1, 6\*</sup>, Marit Nesje<sup>2</sup>, Lughano JM Kusiluka<sup>3</sup>, Sebastian W Chenyambuga<sup>4</sup> and Bjørn P Kaltenborn<sup>5</sup>**

<sup>1</sup>Department of Basic Sciences & Aquatic Medicine, Norwegian School of Veterinary Science, PO Box 8146 Dep., N – 0033 Oslo, Norway; Fax: +47-22466072; e-mail: nstelbi@yahoo.co.uk

<sup>2</sup>Department of Production Animal Clinical Science, Norwegian School of Veterinary Science, PO Box 8146 Dep., N – 0033 Oslo, Norway; e-mail: Marit.Nesje@nvh.no

<sup>3</sup>Department of Veterinary Medicine and Public Health, Faculty of Veterinary Medicine, Sokoine University of Agriculture, PO Box 3021, Morogoro, Tanzania; e-mail: ljmkusiluka@yahoo.com

<sup>4</sup>Department of Animal Science and Production, Faculty of Agriculture, Sokoine University of Agriculture, PO Box 3004, Morogoro, Tanzania; e-mail: chenyasw@yahoo.com

<sup>5</sup>Norwegian Institute for Nature Research (NINA), Fakkeltgården, Storhove, N-2624 Lillehammer, Norway; e-mail: bjorn.kaltenborn@nina.no

<sup>6</sup>Ministry of Livestock Development and Fisheries - Veterinary Investigation Centre - Temeke, P.O Box 9254 Dar-Es-Salaam, Tanzania; e-mail: nstelbi@yahoo.co.uk

\* Corresponding author: Stella Bitanyi; e-mail: nstelbi@yahoo.co.uk

### Abstract

Examining local awareness and perceptions of illegal resource harvesting is a difficult but necessary part of designing efficient wildlife resources conservation programs. We examined awareness and attitudes related to wildlife hunting practices among local communities in the Magu, Bunda and Serengeti districts in the western part of Serengeti National Park, Tanzania. We also examined the influences of socio-demographic variables on awareness of hunting and some of the methodological challenges linked to researching sensitive resource topics. Members of these communities were fairly aware of the occurrence of illegal hunting practices, as well as the modalities of existing law enforcement, but knowledge about legal hunting systems was limited. The extent of awareness of these practices and attitudes towards them were significantly affected by age, gender, and level of education, with limited awareness observed among women and those with higher education levels. Observed challenges were mostly related to respondents' attitudes and sensitivity to illegal wildlife uses, including fear to disclose information and non-responses to specific questions. The relatively extensive awareness of illegal hunting practices probably reflects community members' involvement in illegal wildlife use. Improved education programs are needed as well as provision of alternative livelihood opportunities that may decrease dependence on wildlife resources.

**Key words:** western Serengeti, illegal hunting, local awareness, perceptions, conservation.

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## Introduction

Bush meat hunting has been an important subsistence activity in many rural parts of Africa throughout history [1-3]. Bush meat serves as a key protein source [3, 4] and provides an alternative to livestock meat, especially in areas where tsetse flies are prevalent [2]. However, extensive bush meat hunting often causes pressures on various wildlife species, leading to their decline [5-7], and frequently involves illegal hunting. In Central and West Africa, bush meat off take has been observed to occur at unsustainable levels, with harvest levels estimated to range from 1 to 3.4 million tons per year [1]. Increased and unsustainable levels of hunting have been a major cause of biodiversity loss and decline in wildlife populations throughout Africa [3, 4, 8, 9, 10], often impacting the effective size of protected areas [11]. Poaching threatens not only wildlife, but also local fish and plant populations. From an equity perspective, poaching deprives legitimate users, consumptive as well as non-consumptive, of resource utilization opportunities [12]. Unregulated hunting may also increase the danger of transmission of zoonotic diseases [13]. In this context we use the terms “poaching” and “illegal hunting” interchangeably and to mean any form of harvesting of wildlife that is not in line with laws and management regulations, is conducted without a hunting permit, or is otherwise at odds with relevant legal and policy instruments.

Despite existing laws and regulations regarding hunting in Africa, it is difficult to restrict the use of bush meat, as many rural people depend upon it to meet their basic nutritional needs [14]. Poverty is known to be a major driver for illegal hunting by people living around protected areas [15-17]. Increased human populations around protected areas such as Serengeti National Park (SNP) result in escalating pressures on wildlife resources, and greater population densities are known to exacerbate illegal hunting [6, 15, 18, 19].

Since bush meat hunting is typical of areas with low food security and few realistic alternative meat sources, understanding the social contexts of communities in rural areas is essential for developing strategies to reducing the problem [20]. In order to identify the drivers behind and levels of bush meat hunting, consumption, and trade in the communities around national parks and game reserves, it is necessary to obtain a realistic picture of how local populations perceive and understand specific social issues and livelihood conditions. It is widely accepted that current biodiversity loss and poverty are linked, and that poverty and conservation must be recognized and addressed as interlocking challenges [21]. A sustainable livelihoods approach [22, 23] links social and ecological criteria, and examines the differential capability of rural households to cope with crises such as food shortages, floods, droughts, and diseases [24]. Sustainable livelihoods are linked to vulnerability, competence, and knowledge [25], and include human, ecological, economic, and physical assets [22, 26, 27]. In the bush meat context, a key variable is the local knowledge component of the resource use patterns. Research on knowledge and local perceptions of sensitive issues like illegal hunting can indicate gaps that may obstruct sustainable use and conservation efforts.

We have three objectives with this study. First we examine the level of awareness of communities in the Serengeti ecosystem regarding illegal hunting, legal hunting practices, and perceptions of law enforcement. Secondly we assess the influences of socio-demographic factors on local awareness of illegal hunting and perceptions of law enforcement, and thirdly we elaborate on some of the methodological challenges of researching a sensitive issue like poaching.

### *Hunting and management interventions in the Serengeti ecosystem*

The people of western Serengeti (Figure 1) are dominantly agro-pastoralists, relying on both livestock and crop cultivation for their subsistence. The population is composed of more than 20 ethnic groups, with Ikoma, Ikizu, Kurya, Natta, Issenye, Zanaki, Jita, Taturu, Luo, and Sukuma predominating [ 28, 29]. The current population in western Serengeti is estimated to be about 2 million people [30], with

the Serengeti district alone having an annual growth rate of 3.1% [31]. Agriculture is practiced at a small scale, with maize, cassava, millet, and sorghum cultivated for food and cotton cultivated as a cash crop. The main livestock kept in the area are cattle, goats, sheep, pigs, donkeys, and poultry. Crop agriculture and livestock account for around 80% of the average household income; the remaining 20% is obtained from off-farm activities, such as hunting, charcoal making, making local brew, and salaried employment [15, 18, 32]. The estimated individual annual income from livestock ranges from US\$ 45 to 130. Additionally, illegal hunting is reported to contribute an annual income of US\$ 200 to illegal hunters, a value close to or equivalent to average on-farm income [33].

Illegal hunting is widespread in the Serengeti ecosystem [34]. Hunters from local communities rely on bows and arrows, pitfall traps, and snares, snares being the most preferred method [35]. The practice is deeply rooted in the culture of Kuria and Ikoma tribes, and is closely associated with the annual wildebeest migration season [36]. The Ikoma tribe has been reported to be responsible for nearly 40 % of illegal hunting practices in the ecosystem [37]. Besides the cultural motives, illegal hunting in Serengeti is also motivated by economic reasons and the need for food [2, 6, 15, 16, 33, 38, 39]. Like other parts of Africa, the rates of illegal hunting in Serengeti vary among villages and are independent of market prices and consumers' preferences of species [6, 16, 40].

The numbers of illegal hunters in the areas 45 km west of SNP and its adjacent protected areas have been estimated to range from 52,000 to 60,000, a 90% increase from 1988 to 1998 national census data [15, 38, 41]; however, the estimates are much debated and there is considerable uncertainty about the number of illegal hunters as well as the off take within the ecosystem. Recently Hilborn et al. [42] suggested a decrease in illegal hunting activities as a result of intensified antipoaching patrols. Usually, the meat is dried and sold locally at prices that are affordable to the community. Trading methods include local house-to-house sales within the village area, contracts between hunters and end-consumers, or involvement of middlemen traders [2]. Among the wildlife species in the Serengeti ecosystem, resident herbivore species have reportedly experienced significant hunting pressures, with estimates of annual illegal harvests close to 210,000 animals [18].

Establishment of wildlife management areas (WMA) in Serengeti and other protected areas in Tanzania signify efforts to involve local people in sustainable utilization and conservation of wildlife [43]. Currently, the Ikona WMA in Serengeti targets community-based tourism development by signing deals with foreign and local investors, who in turn have to share derived benefits with the local communities. However, following privatization of hunting concessions, local resource use has been restricted, prompting concerns about local rights to utilization and benefits [44]. In addition, initiatives such as the Serengeti Regional Conservation Project (SRCP) and Community Conservation Service (CCS) in the 1990s in western Serengeti aimed at motivating people to contribute towards conservation goals and to align their land-use and resource exploitation with conservation [41, 45]. Despite these initiatives, illegal hunting reportedly has continued in community-based conservation areas, where, among other things, the cultural aspects of hunting have not been adequately addressed by the conservation authorities [36, 38]. The SRCP and CCS experiences reflect what other studies indicate, namely that integrated conservation and development projects largely fail [46, 47], and some go so far as to suggest the approach should be abandoned altogether [39].

One of the reasons many community based conservation efforts fail is that the complex social structure of activities like hunting and traditional land use is either underestimated or simply not understood. Illegal hunting is driven by a range of reasons, and efforts to improve local livelihoods need to be sensitive to why people poach. Simply assuming that poor people seek to acquire food and/or cash by selling and trading meat can mask the complexity of the problem and the actors involved. Reasons for poaching can be as diverse as: household consumption, commercial gain, recreational experiences, building social status in a community, thrills, outsmarting anti-poaching wardens by demonstrating superior knowledge of terrain and hunting, necessity, denial of law,

rebellion against what is perceived as unjust policies, exercising traditional rights, or gamesmanship [12, 48, 49].

Illegal hunting is driven by basic livelihood needs and values and perceptions of what is beneficial, as well as community norms on appropriate and legitimate use of local wildlife resources. Attitudes towards wildlife are influenced by fundamental life values, experiences as well as knowledge [50-52]. Increasing knowledge is associated with more positive attitudes toward conservation [52-56]. Socio-economic and demographic factors have also been shown to affect the extent of knowledge about and perceptions of wildlife hunting. Cross-culturally, people with higher education levels tend to have more knowledge about wildlife conservation issues, and men tend to be more knowledgeable about wildlife than women [57, 58]. Likewise, knowledge of wildlife conservation issues appears to be more extensive among men who are household heads and among people who own more livestock and therefore have a higher economic status in the community [59]. Direct experience with law enforcement also affects perceptions of power and authority [60]. Conceptually, we define awareness as knowledge or understanding obtained through individual special interest or experience [61-63]. We use the term perception to describe individual or collective representations of conditions associated with wildlife and hunting.

## Methods

### *Study design*

Researching illegal hunting is by its nature a difficult task posing methodological and ethical challenges similar to those found in other sensitive social arenas. This entails determining how the social and political contexts influence the responses and interpretations of informants, how probing knowledge of and engagement in illicit activities may evoke negative emotions and fear of retribution, and how to secure sufficient internal and external validity [64-66]. Research into illegal resource use must design an approach that balances the need to provide empirical data, the labor demand, training and technology requirements, and levels of uncontrollable bias and confounding variables [67]. Illegal hunting and other forms of illegal resource utilization have been researched using a variety of techniques such as analyzing law enforcement records, direct and indirect observation, self-reporting, interviewing, randomized response techniques, forensics and modeling – all of which have strengths and weaknesses depending on the particular research subjects and research question [67].

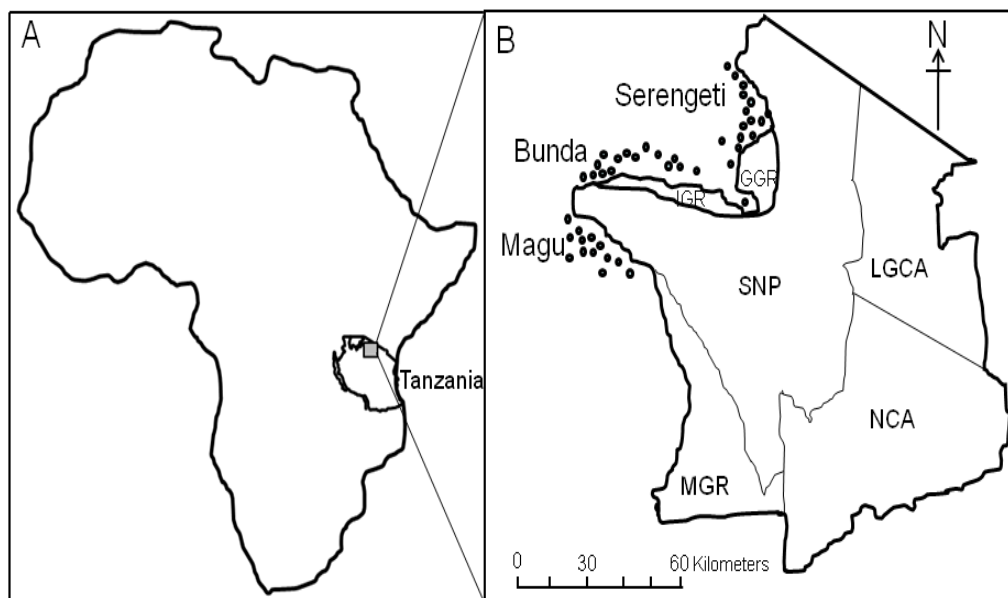
Research on human-wildlife conflicts in Africa has sometimes been criticized for the lack of balance between quantitative (generalizing on population or sub-population levels) and qualitative approaches (necessary for more precise understanding of categories, perceptions, relationships and processes, particularly in a cross-cultural context) [64, 68]. However, the need for improved understanding of the qualitative dimensions of illegal hunting does not exclude the need for estimates of the extent and distribution of illegal activities. In such cases techniques like the randomized response technique (RRT) and other similar approaches may be the appropriate choice, allowing generalization of findings [69]. Equally important, RRT and other quantitative techniques offer more anonymity. They allow respondents to disclose sensitive information in a relatively safe way, since in most cases the interviewer cannot determine a subject's particular response to a potentially incriminating question.

Our choice of a survey approach in this study met the research objective of assessing levels of awareness of an illicit activity in a fairly large population. In terms of internal validity of the poaching phenomenon and socio-political context, our study benefits from previous studies conducted in the Serengeti region and other parts of Tanzania, which have explored the qualitative dimensions of illegal hunting [6, 15, 16, 33, 34, 70-73]; some of these also discuss quantitative dimensions of illegal

hunting. Furthermore, one of the authors in our study conducted a series of in-depth interviews as part of previous studies of human-wildlife conflict and protected area management in the Serengeti region [41, 74].

### Data collection

Data were collected in the Serengeti, Bunda, and Magu districts on the western side of SNP (Fig. 1), where illegal hunting practices are thought to be more prevalent [12, 35, 59]. Villages were randomly selected from each district, the main criterion being that villages should be situated less than ten kilometers from SNP, on the assumption that people in close proximity are more aware of illegal activities and law enforcements. Although distance from SNP was our key concern, we also considered geographical coverage and tribal representation and therefore included a few other villages. We included 43 villages, 15 from both Serengeti and Bunda districts and 13 in Magu district. In each village, the sample unit was the household, randomly selected from village and sub-village registers based on random systematic selection. A mean of  $20.02 \pm \text{SD } 0.15$  people, mainly household heads (both men and women), were interviewed per village. This minimum number was chosen so that at least 5 % of the village households could be represented in the survey. The surveyed villages had 150 – 600 households, which means the survey covered 3 – 13% of the households in each village. If the household head was absent on the occasion of the interview, the most senior person present in the household at the time was interviewed. All interviews were conducted with the consent of the respondents, who were assured anonymity and confidentiality. District Executive Directors provided consent for conducting the study, and in each village, permission to conduct the work was requested from the village leaders following an introduction to the project. Data were collected by personal interviews in Swahili by the first author of this article, assisted by two trained assistants who were familiar with the local environments, using a structured questionnaire comprised of both open-ended and closed questions [75]. The draft survey questions were pre-tested on a pilot sample of 20 households in one village in Serengeti district and adjusted accordingly.



**Fig. 1. Location of Serengeti ecosystem, Tanzania in Africa (A), its protected areas Serengeti National Park (SNP), Ngorongoro Conservation Area (NCA), Grumeti Game Reserve (GGR), Ikorongo Game Reserve (IGR), Maswa Game Reserve (MGR) and Loliondo Game Controlled Area (LGCA), and the location of the villages in the Serengeti, Bunda and Magu districts where questionnaire survey was done (B).**



### *Questionnaire information and analysis*

The questionnaire interview contained questions related to i) household socio-demographics, ii) natural resource use, and iii) awareness of illegal hunting practices, hunting seasons, and legal hunting practices. Respondents were also asked about their perceptions of law enforcement against illegal hunting in the local area. The questions were both closed and open ended. Closed-ended questions could be answered with Yes, No, or Do not Know, and were subsequently followed by open questions that were later coded for analyses. Information on household characteristics proved unproblematic to gather, while information on illegal hunting proved more sensitive and required some probing and assurances of confidentiality from the interviewer. Despite the assurance of confidentiality, specific non-responses to sensitive questions were observed. The use of a large sample size and inclusion of a wider range of factors to assess awareness were used to increase the strength of the information obtained. On certain sensitive questions we achieved a response rate of less than fifty per cent, and we subsequently interpret and discuss these findings with caution and emphasize potentially confounding variables. Statements from open-ended questions were coded and analyzed using the Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago). Occurrence of illegal hunting activities in the villages, knowledge about hunting seasons and legal hunting, and levels of law enforcement were reported descriptively by frequencies and percentages. Linear regression analysis was used to determine the degree of association between socio-demographic factors (age groups, gender, livestock ownership, position in the household, and size of the household) and awareness of: a) illegal hunting, b) legal hunting practices, and c) law enforcement against illegal hunting. The results from the linear regression analyses were reported as estimated coefficient (B), standard error of the coefficient (SE), Student's t-test statistic (t), and level of statistical significance (p). The associations were considered to be significant at  $p \leq 0.05$ .

## **Results**

### *Characteristics of respondents*

The sample comprised 61 per cent men ( $n=526$ ) and 39 per cent ( $n=335$ ) women. The overrepresentation of men may be partly due to the study design, where household heads were the main targets for the interviews, and the fact that in our study area most households are male-headed, except for a few households headed by widowed and unmarried women. Household heads comprised 51% of the respondents, while wives, sons and daughters, and other family relatives represented 28%, 12%, and 10% respectively. The majority of the respondents were in the age group of 21 - 40 years old (57%), and a few belonged to older age groups > 61 years old (9%). The majority (79%) of the respondents had completed primary school education, 8% of them secondary school education and above, while some (14%) had no formal education at all. The majority of households were made up of 6 – 10 (53%) and 1 – 5 persons (27%). Livestock keeping was practiced by 78% of the households. The ethnic representation was more skewed to the Sukuma tribe (41%), while the tribes of Kuria (18%), Ikizu (10%), Ikona (10%), Issenye (3%), and Jita (2%) were also represented. Other tribes representing at least one percent of the sample were Taturu, Sizaki, Kisii and Kerewe.

### *Awareness of illegal hunting and use of wildlife resources*

The majority (63%) of those interviewed did not admit using natural resources in the PA bordering their villages. Only 37% of the respondents stated that either they or their family members had entered PA and used wildlife resources. The main reasons for entering PA included livestock grazing, wildlife hunting, firewood gathering, and thatch grass collection (Table 1). The "other uses/reasons" stated by respondents was a large category and includes timber harvesting, fetching water, cultural/rituals purposes, follow-up on animal thefts, chasing/scaring problematic wild animals, and local tourism through good neighborhoods support programs.

About 50% of the respondents reported that illegal hunting occurred in their villages, while the other half of the sample claimed that such hunting did not occur. Regression analysis revealed that gender had a significant association with awareness of illegal hunting activities, with males being more likely to report awareness of this than females (Table 2). There was an inverse relationship between education level and admitting being aware of illegal hunting activities. Although the relationships among gender, education level and awareness were clearly significant, the overall model fit of the regression was not particularly good, indicating high variance. This can probably be attributed to the four other variables in the models that were not significant. Illegal hunting was reported to be a primary source of income to hunters by 13% of the respondents, while 32% reported illegal hunting to be secondary (extra income activity), and 2% reported it as both primary and secondary source of income to the hunters' families. More than one-half (53%) of the respondents declined to answer this question.

Table 1. Use of wildlife natural resources in protected areas (PA) around Serengeti ecosystem – reasons for entering PA cited by respondents

Reasons for entering PA	No. of respondents	% of respondents
Livestock grazing	61	7.1
Hunting	37	5.5
Firewood gathering	36	4.2
Thatch grass collection	19	2.2
Charcoal making	14	1.3
Employed in PA	10	1.2
Collection of building poles	8	0.9
Fishing	2	0.2
Collection of medicinal plants	2	0.2
Mining	1	0.1
Other uses	104	12.1
Did not respond to question	566	65.8

### *Awareness of hunting seasons*

More than one-third (40%) of the persons interviewed stated that they knew about the existence of hunting seasons. The period between July and December was correctly identified as the period when legal trophy hunting is permitted. There was a significant association between gender and position of respondents in the household in relation to awareness about hunting seasons, with males and household heads more likely to report awareness than others (Table 3). However, education showed an inverse relationship with awareness of hunting seasons. The same caution about the overall regression model applies here. Those persons who knew about hunting seasons in the PA were asked to list the reasons and/or importance for having a no- hunting season. Reasons provided by the respondents included: providing sufficient time for animals to reproduce (29%), migration to other areas with good pastures (12%), limitation on hunting due to decreased numbers of wild animals in the ecosystem (10%), and a conservation strategy by the government to avoid over exploitation (1%). The remainder of the people interviewed did not offer suggestions for why there was a no-hunting season.

### *Legal hunting practices*

The majority of those who participated in the study (87%) claimed that they did not wish to hold a hunting license, but a few (9%) expressed an interest in obtaining one. The remaining four percent chose not to respond to the question. Some of the respondents who expressed interest in having a



license had previously held licenses, and among those who expressed no interest in having a hunting license none had held a license before. As to why the interviewees no longer use hunting licenses, 29 % stated correctly that the government no longer grants hunting licenses to local people. The other respondents did not answer this question.

We found a significant association between both gender and age and the desire to have a hunting license, with males and older people reporting a stronger preference for licenses (Table 4). The majority of respondents (89%) did not have any knowledge about licensed trophy hunting. Furthermore, those respondents who had some knowledge about licensed trophy hunting described the practice as: licenses only given to foreign tourists (43 %), licenses that were valid for one hunting season in a year (22 %), and that fees obtained from trophy hunting were a source of government revenue (35 %). Although these responses were based more on local understandings, they accurately described the practice.

Table 2. Effects of demographic variables on awareness about the occurrence of illegal hunting practices among the villagers in western Serengeti ( $R^2 = 0.041$ ). Key: B=estimated coefficient, SE=standard error of the coefficient, t=Students t-test statistic and p=level of statistical significance

Variable	B	SE	t	P
Gender	0.149	0.0037	4.065	0.000
Age	0.031	0.025	1.260	0.208
Education	-0.108	0.039	-2.793	0.005
Livestock ownership	-0.041	0.042	-0.982	0.326
Position in household	0.007	0.010	0.773	0.440
Size of household	-0.015	0.020	-0.774	0.439

### *Perceptions of law enforcement*

Two-thirds (66 %) of the respondents were aware of anti-poaching authorities and law enforcement targeting illegal hunting. Respondents from Serengeti and Bunda districts showed the highest levels of awareness (both districts 43 %), while those in Magu district showed the lowest level of awareness (14%). Awareness of law enforcement differed among the major tribes represented in the sample. The highest awareness of anti-poaching authorities was observed in the Issenye tribe (96%), followed by Ikizu (79 %), Ikoma (79 %) and Kuria (76 %) tribes. The lowest level of awareness was found in the Sukuma tribe (47%). None of the demographic variables investigated had a significant association with awareness of law enforcement in the area (Table 5). Relevant authorities in the area were identified as game guards from Tanzania National Parks Authority (TANAPA) and Grumeti Reserves, village game scouts, and government authorities at district levels. These authorities were known to conduct anti-poaching patrols in Game Reserves, villages and the SNP in order to apprehend persons involved in illegal hunting of wildlife. The respondents listed various consequences they believed were imposed on those apprehended for illegal hunting, including: prison sentences (46%), fines (19%), appearance before courts resulting in imprisonment and/or paying of fines (24%), punishment by village authorities (7%), and on-site punishment by the game rangers (4%).

Table 3. Effects of demographic variables on awareness about hunting seasons in western Serengeti ( $R^2=0.068$ ). Key: B=estimated coefficient, SE=standard error of the coefficient, t=Students t-test statistic and p=level of statistical significance.

Variable	B	SE	t value	P
Gender	0.145	0.032	4.559	0.000
Age	-0.016	0.022	-0.748	0.454
Education	-0.110	0.034	-3.249	0.001
Livestock ownership	0.040	0.036	1.101	0.271
Position in household	0.023	0.008	2.685	0.007
Size of household	-0.032	0.017	-1.830	0.068

## Discussion

The interviews in the three districts clearly indicate community involvement in illegal uses of wildlife resources, although a large percentage of the informants denied relying on natural resources from Serengeti National Park. A parallel study by Bitanyi et al [ 76] recovered diverse species from bush meat specimens collected from the same communities, supporting the finding that bush meat harvesting and consumption are still active practices in this region. This further underscores the need for different methods of verification in researching and monitoring sensitive topics like illegal wildlife uses.

In Tanzania, both land and wildlife are state owned and the government is responsible for issuing permits for hunting. Legal hunting is based on a quota system set out annually in hunting blocks [77], where both tourists and resident hunters are permitted to hunt if they possess valid (and expensive) licenses issued by the Wildlife Division, and otherwise fulfill the requirements of legally possessing a firearm, having access to a vehicle, and being older than 18 years [78]. Yet, local people continue hunting illegally as they are neither able to afford licensing fees nor allowed to use traditional weapons under the current legislation. In reality, legal hunting is not an option for local people in areas like Serengeti, since no hunting quotas are granted to local people at affordable terms. For local hunters, the economic benefits from sales of illegally acquired bush meat are far greater than the costs associated with a low probability of arrest and prosecution. The result is a persistent problem for wildlife conservation [15, 35].

Table 4. Effects of demographic variables on admitting to the wish to be able to obtain a hunting license in western Serengeti ( $R^2=0.052$ ). Key: B=estimated coefficient, SE=standard error of the coefficient, t=Students t-test statistic and p=level of statistical significance.

Variable	B	SE	t value	P
Gender	0.186	0.033	5.550	0.000
Age	0.065	0.023	2.879	0.004
Education	-0.006	0.035	-0.160	0.873
Livestock ownership	0.073	0.038	1.914	0.056
Position in household	0.008	0.009	0.867	0.386
Size of household	-0.016	0.018	-0.860	0.390

The rather low level of awareness of hunting seasons can partially be explained by the current situation in western Serengeti, where community involvement in legal hunting practices has been significantly restricted. However, despite the fact that we identified limited awareness of legal seasons, local perspectives of the importance of prohibiting and/or limiting hunting seasons were largely in line with the ecological reasons for regulating harvest. Judging from previous studies and the findings in this study, it is fair to assume that the magnitude of the illegal harvesting of game meat is still considerable in this region. In light of this, relatively few respondents expressed a desire to acquire legal hunting licenses as a means to obtain legal and cheaper meat, and thereby contribute to a more sustainable harvesting regime. It may simply be that illegal hunting is currently seen by many as a more accessible option than licensed hunting. As long as this is the case, high rates of illegal hunting could continue to seriously undermine any efforts to establish sustainable legal hunting practices.

Table 5. Effects of demographic variables on awareness of law enforcement regarding hunting restrictions ( $R^2=0.014$ ). Key: B=estimated coefficient, SE=standard error of the coefficient, t=Students t-test statistic and p=level of statistical significance.

Variable	B	SE	t value	P
Gender	0.064	0.036	1.790	0.074
Age	-0.038	0.024	-1.564	0.118
Education	0.005	0.038	0.123	0.902
Livestock ownership	0.063	0.041	1.526	0.127
Position in household	-0.012	0.009	-1.282	0.200
Size of household	0.018	0.019	0.941	0.347

Informants from tribes like Kuria and Ikoma that are reputed to have strong hunting traditions reported more extensive awareness of law enforcement efforts. These tribes are known to depend largely on wildlife through consumption of bush meat [36, 37], and therefore it is not surprising that they are better informed about hunting restrictions and regulations that may affect their daily livelihood. Observed differences in awareness of illegal hunting and hunting seasons among men and women may partly be due to gender-based differences in division of labor rather than differences in attitudes toward wildlife between men and women. For example, extensive awareness among men may be linked to their exclusive involvement in fishing and hunting [79]. Women on the other hand focus on agricultural production and daily livelihood chores [79], and this, along with various social norms that restrict women, may limit their access to and knowledge of wildlife resources [80]. Surprisingly, higher levels of education were to some extent associated with less awareness of hunting and hunting seasons, somewhat contrary to other wildlife studies [57, 58]. One interpretation could be that increasing opportunities for employment based on higher education may decrease dependence on wildlife resources and reduce interest in wildlife as a resource [81].

Current management regimes in the various protected areas in the Serengeti ecosystem are heavily based on restricting resource use and land access. Previous promises by decision makers and managers that communities would gain more control over wildlife resources through the implementation of wildlife management areas raised expectations that have not been met. The continued top-down, government-based management as well as increased private investments that restrict resources uses by communities have probably increased negative local sentiments (44). Revenues from WMAs have been shown to benefit few involved villages, which have also experienced

conflicts over the sharing of benefits [82, 83]. Generally, the benefits of WMA have not been visible to local people, and like other villages they continue to suffer opportunity costs associated with restrictions on resource uses, including bush meat hunting. Increased restrictions are also seen in the Tudor Jones /VIP/ Grumeti Reserves investment, where the company took over all village hunting quota shares and restricted local access to lands [84]. Although the company has done a great deal to help communities in building schools and dispensaries and providing employment to some, a great number of individuals receive no direct benefits.

We suggest that continued illegal hunting activities in the area are largely the effect of the sum of restrictions on resource uses imposed by current conservation efforts and management regimes. Limitations on natural resource uses may be seen as a denial of traditional rights, especially among communities with strong attachments to wildlife. The effect can be diminishing community support for conservation [54, 85, 86, 87], which in turn may translate into increased involvement in illegal resource harvesting [7].

Research on illegal use of natural resources faces several methodological challenges [67]. It is evident that community members share awareness of the laws protecting wildlife, but the format and mode of the interview situation, where individuals are exposed and identified, may have affected their responses. We observed confounding variables that were mostly associated with the respondents' attitudes, including the fear of disclosing information and specific non-responses to sensitive questions on illegal hunting. Likewise, some respondents seemed to provide information defending the communities against the legal systems. This phenomenon was observed by Knucl and colleague in interviews involving sensitive issues, where respondents tended to give information considered to be socially desirable rather than reflecting the true community behavior [88]. Although respondents were assured of confidentiality during the interviews, validity of data still remains a challenge, as potential legal retributions can be formidable. In most cases we believe these results to under-report the level of community involvement in poaching, the importance of game meat to local diets, and the amount and diversity of poached game. The relatively high non-response pattern to some of the questions reflects perceived obligations to a shared community ethic and the basic issue of self-protection.

At least three implications can be drawn from this. First, the choice of appropriate study design and methods depends on how much one already knows about the illegal resource harvesting in the particular area. If the qualitative dimensions are well defined (*i.e.*, the drivers, the social dynamics and the actors), distributive mapping and other quantitative approaches can be feasible and useful for ascertaining the extent and magnitude of the problem. However, survey-based research and other mapping techniques may be both premature and ethically doubtful in cases where the local context is insufficiently understood.

Secondly, some issues or contexts may be so sensitive that any method that can potentially link a particular informant to substantive answers or pieces of information has to be ruled out. In such cases the only options may be techniques like randomized response technique (RRT) and unmatched count techniques (UCT), offering anonymity and confidentiality to respondents, although they may not capture the qualitative aspects of the phenomenon well. Focus groups can function in moderately contentious situations, since they more or less express the norms and views of the group while providing some protection to the individual.

Thirdly, triangulation of different data collection techniques can greatly improve both the internal and external validity of data in cases involving illegal resource use. In the case of bush meat this can be

achieved by combining interviews, participant observation and forensics. In most cases this will require cooperation between natural and social scientists.

### Implications for conservation

Communities in western Serengeti are involved in wildlife hunting not because they lack knowledge about the illegality of wildlife hunting and the importance of conservation of wildlife species, but because they lack alternative sources of meat. Although the current wildlife policy promotes the involvement of people in wildlife conservation, the current reality in the western Serengeti is that local residents seldom benefit from direct use of wildlife resources. This further highlights the need for diversifying sources of income and for adoption of poverty reduction policies that are conservation-friendly to help provide sustainable livelihood opportunities in local communities. The strategies may include appropriate and adequate support for the agricultural sector as means to increase local food security. Support measures could include subsidizing farming inputs such as fertilizers, providing small and affordable loans, and enhancing access to markets for their produce. Further measures to increase livelihood security include income generating activities that are as profitable and culturally significant as hunting to reduce dependence on wildlife resources. Continual education programs to enhance community knowledge and involvement in wildlife conservation are important for long term survival of wildlife habitat and species. Such initiatives should provide opportunities for people to become involved in wildlife conservation as peer educators and become important and trusted persons in their communities. Knowledge can also be enhanced by incorporating wildlife conservation programs into primary and secondary school curricula. The establishment of wildlife information centers in villages or at ward level might also be useful in enhancing knowledge skills and increasing awareness.

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