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Socioeconomic and health implications of human–wildlife interactions in Nthongoni, Eastern Kenya

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The human population in Kenya has doubled over the last 25 years and is expected to rise twofold by 2050. Thus, pressure for human space has led to encroachment into wildlife habitats, increasing human–wildlife interactions. Such interactions pose serious health risks to both humans and wildlife, yet studies to understand these risks are limited in Kenya. To understand the possible predisposing factors for zoonoses at the human–wildlife interface, a survey was carried out in Nthongoni, an area bordering Tsavo and Chyulu Hills national parks in Kenya. Questionnaires were administered to 11 key informants and 200 residents from 35 villages. Our results indicate that the majority (75%) of the respondents suffered from crop raids and livestock depredation by wildlife. On their part, residents killed wildlife for: subsistence (41%), revenge (35%), bush-meat trade (22%), and other undisclosed reasons. Nineteen per cent of the respondents were knowledgeable about disease transmission through bush-meat. Qualitative data revealed helplessness, bitterness and revenge tendencies by farmers due to wildlife losses, which contributed to their poverty. This study enhances our understanding of human–wildlife interactions and the associated socioeconomic, health and conservation implications. It demonstrates the predicaments communities living adjacent to wildlife areas face and the need to involve them in sustainable management of the areas. We recommend identification of appropriate alternative livelihoods, to mitigate illegal bush-meat and agricultural practices that attract wildlife, leading to conflicts. In addition, responsive health and conservation education, and participatory research aimed at advising policy, are necessary to cushion the communities from wildlife damages.

Key words: human–wildlife conflict, crop raiding, bushmeat, zoonoses, wildlife areas.

INTRODUCTION

Humans and wildlife have always coexisted. However, several factors have increasingly compromised this situation over the last few decades. Rapid growth in the human population, accompanied by unprecedented mobility, for example, has dramatically increased the number of people living in close proximity to wildlife, heightening an overlap of human and wildlife needs (Madden, 2004; Patterson, Kasiki, Selempo & Kays, 2004; Muruthi, 2005; King, Douglas-Hamilton & Vollrath, 2011). In Kenya, for instance, the human population has doubled over the last two and a half decades and is expected to rise twofold by 2050 (Thuku, Gachanja & Obere, 2013). This increase intensifies competition over diminishing resources and promotes environmental degradation. Practices such as clearing forests for cultivation, logging for fuel wood, and overgrazing, among others, exacerbate the situation (Wallis & Lee, 1999; Gillespie, Chapman & Greiner, 2005; Mbora & McPeek, 2009). Furthermore, recent economic developments have fuelled a change in rural economies from traditional subsistence farming or hunting and gathering to commercial activities (Nyamasyo & Kihima, 2014). Moreover, improved infrastructure has eased accessibility of previously pristine and geographically isolated areas (BCTF, 2003), further exacerbating natural resource exploitation. These factors negatively affect the lives of the local communities, the wildlife and the associated habitats (Mbora & McPeek, 2009; Kivai, 2010). In addition,

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climatic changes such as prolonged droughts result in reduced food resources available for both wildlife and humans, forcing animals to stray into human habitats (FAO, 2009, Makindi, Mutinda, Olekaikai, Olelebo & Aboud, 2014). On the other hand, during the wet seasons, prey species are dispersed, which may constrain food access for carnivores forcing them to kill livestock for food (Patterson *et al*., 2004; Western & Manzolillo-Nightingale, 2004). Thus, environmental changes potentially provoke human–wildlife conflict with profound consequences on the ecosystem, the wildlife and humans themselves.

Human–wildlife conflicts are a global concern in terms of conservation and the socioeconomies of local people (Woodroffe, Thirgood & Rabinowitz, 2005; Naidoo *et al*., 2006; Dickman, 2010). However, the level of vulnerability of people living in remote rural areas in developing countries is intensified compared to those inhabiting developed nations (FAO, 2009; McGuinness, 2016). Within developing countries, the poor farmers and pastoralists bordering wildlife areas suffer most of the crop losses, domestic stock predation, and human injuries or loss of life (Njagi, 1995; Hill, Osborn & Plumptre, 2002; Dickman, 2010; Hill, 2015). Most rural communities in Kenya and in Africa at large depend on subsistence agriculture and livestock keeping as an important source of household food and income (Speca, 2013; Wallace & Hill, 2016). Crop raiding and livestock attacks therefore jeopardize their livelihood and socioeconomic well-being.

Human–wildlife conflict around the Chyulu hills and Tsavo ecosystems has been reported in previous studies (Okello, 2005; Kioko, Okello & Muruthi, 2006a; Muriuki *et al*., 2011a; Kamau & Medley, 2014; Makindi *et al*., 2014; Muendo, 2015). These studies reveal increasing human settlement in the area and subsequent land-cover changes resulting from anthropogenic activities. For instance, human–elephant (*Loxodonta africana*) conflicts have increased in these areas (Kioko, Kiringe & Omandi, 2006b), intentional fires leading to wildlife habitat loss are now more common than before (Kamau & Medley, 2014) and overall land cover has shown significant decline over the last four decades (Muriuki *et al*., 2011a; Muendo, 2015). Despite this compelling evidence of land use changes and increased human–wildlife interactions, studies on the likely risks of zoonotic infections due to such entanglements are largely missing.

Increased interaction between humans and wildlife is likely to enhance transmission of zoonotic infections (Boyd, 1999; Wolfe, 2005; Fuentes, 2006; Singer, 2010; Brown & Kelly, 2014). Animal contact, handling faecal matter or sustaining scratches or bites from animals are some of the direct means through which disease-causing organisms can be transmitted. Zoonotic pathogens range from gastrointestinal helminths (Munene *et al*., 1998), viruses causing diseases such as the recent Ebola outbreak in West Africa (CDC, 2015), and bacteria such as anthrax, tuberculosis, *Staphylococcus*, *Shigella* and *Salmonella* (Cantas & Suer, 2014). Beside humans, domestic animals also suffer from diseases transmitted to them by wildlife (FAO, 2009), and there are cases where wildlife are reported to have acquired diseases from humans. Mbora & McPeek (2009), for example, highlighted increased parasite prevalence in threatened primates, as a result of human/non-human primate interactions, and land-use change and fragmentation. Previous studies at the human–wildlife interface of Tsavo and Amboseli national parks, Kenya have shown that non-human primates harbour zoonotic parasites such as *Schistosoma mansoni*, *Trichuris trichura*, *Babesia* spp., and *Leishmania* spp. (Maamun *et al*., 2011; Akinyi *et al*., 2013).

Given the socioeconomic constraints and health risks that are likely to result from increased human–wildlife interactions, a thorough understanding of the forms and consequences of such interactions is critical in seeking sustainable mitigation measures that promote human–wildlife coexistence. This study, therefore, aimed to document the socioeconomic status of the people living adjacent to Chyulu and Tsavo national parks, their interactions with wildlife, and how such interactions impact on both human and wildlife's well-being with a specific focus on use of bush-meat. Few studies have incorporated research into human–wildlife conflict, consumption of bush-meat and associated health risks. The knowledge gained will serve as an educational tool to foster wildlife conservation in Tsavo and Chyulu national parks, and to create awareness of the health risks of bush-meat handling and consumption. In addition, the insights gained will serve as a campaign tool for advocating for sustainable livelihoods for the local people who depend on natural resources to survive, and inform government policies to mitigate the livelihood losses borne from wildlife.

METHODS

Study area

The study was conducted in Nthongoni, Mtito-Andei division, Makueni County, in the Eastern province of Kenya. Nthongoni borders Tsavo-West National Park to the South and Chyulu Hills National Park to the West (Fig. 1). It lies between N 1°35′S and 37°10′E, at an altitude of between 600 m and 1000 m above sea level.

The wildlife diversity in the area includes; African elephants, black rhinoceros (*Diceros bicornis*), giraffes (*Giraffa camelopardalis*), eland (*Tragelaphus oryx*), impala (*Aepyceros melampus*), dik-diks (*Madoqua* spp.), buffalo (*Syncerus caffer*), baboons (*Papio cynocephalus*), vervet monkeys (*Chlorocebus pygerythrus*) and Sykes monkeys (*Cercopithecus albogularis*), and major predators such as lions (*Panthera leo nubica*) and leopards (*Panthera pardus*) among other animals (Musila *et al*., 2011). The area is characterized by a diversity of habitats ranging from savanna bush and semi-arid scrub as the dominant land cover, to *Acacia* woodland, belts of riparian forest, palm thickets and mountainous forests on the Chyulu Hills (Wato, Wahungu & Okello, 2006). The soils are of volcanic origin and basaltic rocks dominate the area, particularly around Chyulu hills. The climate is hot and dry for most of the year and rainfall is unreliable, erratic and poorly distributed (Mwongela, 2015). Nonetheless, the region generally experiences a bimodal rainfall pattern that ranges from 150 mm to 650 mm per annum. Short rains occur between October and December and long rains between March and June. Temperatures and evapotranspiration are high with mean monthly temperatures at 28°C (TAWSB, 2011). The area has experienced a series of prolonged droughts that have at times resulted to serious famines. Muriuki *et al.* (2011b) pinpoints some of the severe famines locally named: *Yua ya Namba* (1964), *Longosa* (1974–1975), *Nikua Ngwete* (1981–1982), and *Ndukambikwatie* (1984–1985).

Historical background of human land-use and settlement in Nthongoni

Traditionally, Nthongoni was used as grazing fields by Maasai people where it provided reserve pasture and water during the dry period (Muriuki, *et al.,* 2011b). The community, however, had little

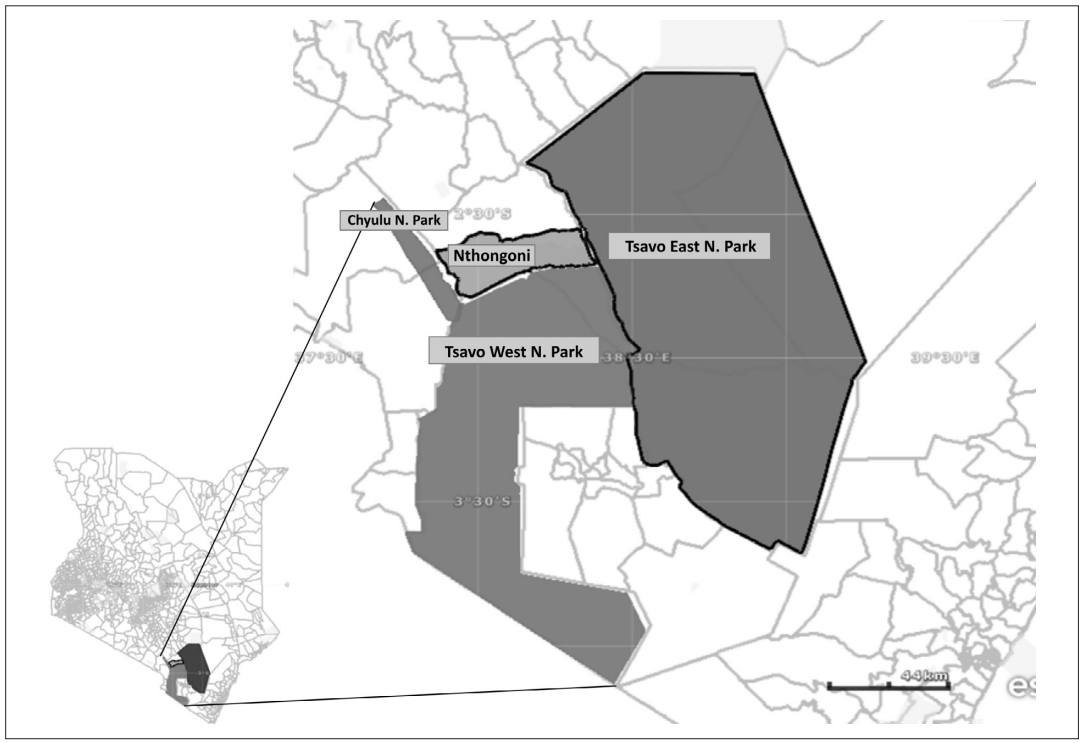

Fig. 1. Map of Kenya showing Nthongoni and the surrounding national parks. Sourced (with modifications) from ILRI (1998).

impact on the land as they did not do any cultivation, poaching or clearing of forests. Although the Maasai's favourite foods were milk, meat and blood, they scorned any kind of game meat, birds or fish (Masterjohn, 2011). Besides, their nomadic way of life only allowed them seasonal encampment before they moved on to other areas.

Sedentary settlement, mostly by the Kamba community, started at the turn of the 20th century. The Ngulia people, a hunter-gatherer sub-tribe of the Kamba community that had occupied the core of Tsavo West National Park, also settled in the area after they were pushed up North, during the colonial period (Kivai, 2008). However, they were all evicted by the British colonial government under the Native Reserves Ordinance of 1902, and the land declared a state property (Lawrence & Mwanzia, 2004). Permanent settlement resumed in 1949 when some communities who had been displaced by a white settler in the upper parts of the district were settled by the then colonial government. Upon independence in 1963, more people were settled by the Kenyan government. In addition, due to human population pressure in other parts of Ukambani, particularly Kilungu, Machakos, Kangundo and upper Makueni, the area experienced mass immigration and settlement. During this period, the Kamba community kept large herds of cattle (*Bos taurus*) and practiced minimal farming, until the famous drought of *Longosa* which wiped out the majority of their livestock and the wildlife in the region (Kivai, 2008).

To date, settlement in the Nthongoni area is yet to be formalized and people continue to be squatters on government land as they do not hold any land ownership documents (title deeds). The majority of the residents currently occupying the area are Kamba, with a few Kikuyu who were settled in the area by the Kenyan government post-independence (Muriuki *et al*., 2011a). Because of the lack of title deeds, the residents live in a pervasive sense of uncertainty. Moreover, they bear considerable costs by coexisting with wildlife, which compromises their living standards (Siex and Struhsaker, 1999). Muriuki *et al.* (2011a) observes that the people have been slow to assert themselves against perceived injustices and failed service delivery for fear that government officials might start questioning their rights to occupy the land. Poor socioeconomic status and the lack of long-term stakes in the land also reduces their motivation to invest and actively engage in the conservation of natural resources. Nevertheless, land adjudication has been ongoing since 2013 (Kipruto, 2016), and this is hoped to assuage the community's fears in the future, and open up space for discussions on alternative livelihood options that may include tourism-related activities to preserve the ecosystem (Muriuki *et al*., 2011a).

Data collection

Prior to commencement of the study, ethical approval was sought and secured locally from the National Commission for Science, Technology and Innovation (NACOSTI) and the Kenya Wildlife Service (KWS). The administrative leaders of the area were also consulted. Data collection was conducted in July and August 2011. Sampling sites were selected based on their proximity (within 1 km) to Tsavo West and Chyulu Hills national parks, and on previous reports of human–wildlife conflict from the local people and KWS. Structured questionnaires, informal interviews and Participatory Rural Appraisal (PRA) were the main instruments used to collect the data.

Participant recruitment

Research participants were purposefully selected from the villages bordering Tsavo-West and Chyulu Hills national parks. Enrolment in the study occurred at the household level, and houses within populated villages were randomly selected based on the number of households. However, in sparsely populated areas, a snowball technique was applied to reach or locate the households. In such places, every household that consented to the survey was included. Family heads, representing households as single units of analysis, were recruited. Where the head of the family was not available, family members, upon consenting to participate, were requested to identify a representative (an adult) to take part in the survey. The key informants were carefully chosen to ensure inclusion of knowledgeable persons from all the relevant stakeholder sections of the community, including local administration, health and conservation officials, village elders and religious leaders.

Questionnaires were administered by three of the authors (M.D.K., A.M. & M.F.) in person to ensure clarity of questions and to probe further on issues requiring more information. The survey was conducted in Swahili, Kenya's national language, and a local assistant was engaged throughout the study, to aid with translation. As it turned out, all the respondents were proficient in Swahili and had no difficulties in understanding or responding to the

research questions. The information was transcribed verbatim and later translated to English. The data collected include demographic details, socioeconomic status and occupational activities of the respondents, human–wildlife conflict experiences, bush-meat consumption, knowledge on possible health risks, and mitigation or deterrence measures. A total of 200 open-ended questionnaires were administered to respondents from 35 villages, while 11 key informants were interviewed. A PRA meeting was also held at the end of the survey, with a total of 52 members of the community who were purposefully selected with the help of the area chief and the village elders. This meeting was intended to confirm issues of interest raised during the survey and to allow further data probing.

Data analysis

Completed questionnaires were numbered and entered into pre-designed MS Excel worksheets and then transposed to MS Statview® (Microsoft, U.S.A.) for analysis. A non-parametric test (Kruskal-Wallis [KW]) was used to compare the different variables of interest in our study. Paired comparisons to establish the source of significance among multiple groups that were investigated, were achieved using a Dunn's test. A coding and theoretical approach was used in managing the qualitative data gathered *via* probing, open-ended questions, PRA meeting and the key informant questionnaires. The data were coded into central themes based on both the participants' perspectives and researchers' own interpretation. The themes were created following closeness and similarity of the responses.

RESULTS

Socio-demographic characteristics of respondents

The sample population of this study comprised 55% female and 45% male. The majority (69%) were married with the other 31% encompassing unmarried (12%), separated/divorced (10%), and windowed (9%). Each household had an average of five children (range: 0–13). Half (50%) of the respondents had attained primary level of education while 31% and 12% had secondary and tertiary education, respectively. Farming was recorded as the largest occupation (75%) followed by formal employment (16%), with the remaining 9% engaged in casual labour and businesses. Although a substantial percentage (33%) could not quantify their monthly income, the majority (75%) of those who could, said they earned less than 35 USD per month (1 USD = 100 Kenya shillings). Sixteen per cent earned between 35 and 110 USD while 9% earned over 110 USD per month.

Land and agricultural activities in Nthongoni

The land tenure system in Nthongoni is freehold. The majority of the respondents (58.5%) claimed to have bought their land, 33.5% to have inherited it, while 3% had rented from others. Most of the respondents (61%) owned less than 2 ha of land with 9.5% owning less than 0.5 ha. The farming activities practiced in the area were the growing of crops (23%), livestock keeping (2%) and mixed farming, mainly agro-pastoralism (75%). Unsurprisingly, the differences at which the three farming activities were practiced varied significantly (H_2 = 257.3, P < 0.0001). *Post hoc* paired comparison analysis also showed the three farming activities statistically different from each other (P < 0.001). Nearly half of the respondents (47%) confirmed participation of both males and females in farming. However, in families where only one gender participated in farming, significant disparities were recorded (H_1 = 90.4, P < 0.0001) with more women (28%) being involved than men (18%). The involvement of children in farming was also reported in 7% of the population.

Types of crops grown in Nthongoni

Maize *(Zea mays*) was the most common crop grown by majority of the farmers in Nthongoni (94.5%), followed by beans (*Phaseolus vulgaris*) (74.5%) and cowpeas (*Vigna unguiculata*) (42%). The other crops grown at a lower scale by the farmers included green grams (*Vigna radiata*) (27%), sorghum (*Sorghum bicolor*) (24%), vegetables (9%), fruits (7%) and cassava (*Manihot esculenta*) (2%). Farming was primarily subsistence (56.5%) although 42.5% of the farmers reported to practice a mixture of both commercial and subsistence farming. Only 1% of the farmers practiced commercial farming exclusively. The three farming systems varied significantly (H_2 = 149.7, P < 0.001). *Post hoc* analysis showed significant variations in subsistence *versus* commercial farming (P < 0.001), subsistence *versus* combined (subsistence and commercial) farming (P < 0.01), and commercial *versus* combined (subsistence and commercial) farming (P < 0.001). Farming was largely done manually (80%) with only 5% of the farmers practicing mechanized farming. The rest

(15%) intermittently mixed both manual and mechanized farming. Farm produce, however, was not adequate and 80% of the families either bought additional food or received relief food from the government, non-governmental organizations (NGOs) and/or well-wishers.

Livestock keeping

The types of livestock kept by farmers included cattle (n = 318, mean = 1.6, range = 0–16), sheep (*Ovis aries*) (n = 143, mean = 0.7, range = 0–15), goats (*Capra aegagrus hircus*) (n = 1266, mean = 6.3, range 0–12) (where: n stands for the total number of animals kept by all the respondents and the 'mean' and 'range' depicts the number kept by individual respondents). Only one respondent kept pigs (*Sus scrofa domesticus*) (n = 12). Chickens (*Gallus gallus domesticus*) and donkeys (*Equus africanus asinus*) were listed in the 'others' category, hence their numbers were not enumerated. The popularity in rearing different animals based on their numbers was statistically significant (H_4 = 412.5, P < 0.0001) with cattle and goats being more preferred by most farmers.

Animals were kept under the following systems: zero grazing (57%), free range (18%) or under combined systems (25%). Comparison of the proportion of farmers practicing the three systems showed they were significantly different (H_2 = 55.0, P < 0.0001). Dunn's multiple test showed that zero grazing was statistically more popular compared to the other systems (zero grazing *versus* free ranging P < 0.001; zero grazing *versus* zero grazing and free ranging combined (P < 0.001), but the difference between free ranging and both (zero grazing and free ranging) was not statistically significant (P > 0.05).

Disease outbreaks in livestock were reported as common by 67% of the respondents with 59% reporting to have experienced an outbreak within the past year prior to the interview. However, the specific diseases were not investigated since it was apparent that not many farmers would be knowledgeable enough to identify the diseases by name.

Crop raids and livestock predation

Eighty-nine per cent of the respondents experienced crop raids, with non-human primates such as baboons and vervet monkeys being the most frequently blamed animals (Fig. 2). The monkeys raided crops at variable rates (H_2 = 111.5, P < 0.0001). Baboons and vervet monkeys raided more than Sykes monkeys but a paired Dunn's test between the species' rates of raiding was not statistically different (P < 0.05). Elephants, buffaloes and antelope were mentioned in the category named 'others'. Livestock predation was reported by 79.5% of the respondents with baboons being reported by 75.5% of respondents as the worst predators of primarily young goats and chickens (Fig. 2). Leopards were reported by 3% and hyaenas (*Crocuta crocuta*) by 1% of the respondents. The rate of livestock predation by the different species of wildlife was found to be significantly different (P < 0.0001). Dunn's multiple comparisons test showed that baboons compared to other non-human primates (vervet and Sykes), hyaenas and leopards, preyed more on livestock. However, the predation caused by hyaenas and leopards was insignificant (P > 0.05). The majority (63%) of the farmers ate the left-overs from crops raided or livestock attacked by the wildlife.

Hunting of wildlife in Nthongoni

Thirty-four per cent of the respondents indicated hunting of wild animals for meat as common in

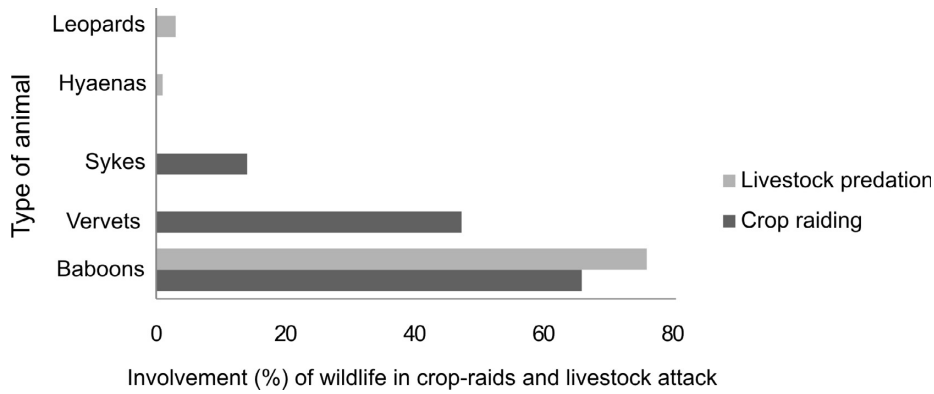

Fig. 2. Percentage frequency of wildlife involvement in crop raids and livestock predation.

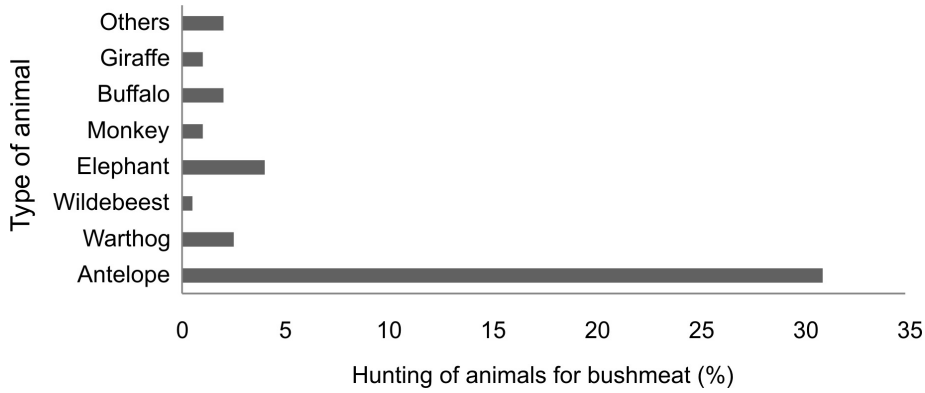

Fig. 3. Percentage frequency of wildlife hunted for bushmeat in the Nthongoni region.

Nthongoni. Antelope species were the most commonly hunted animals as reported by 31% of the respondents (Fig. 3).

The reasons for hunting wildlife included subsistence (41%), revenge for raiding (35%) and bush-meat trade (22%); and these differed significantly ($H_3 = 57.86$, $P < 0.0001$). A Dunn's multiple comparisons test showed significant differences between hunting for subsistence *versus* for commercial purposes ($P < 0.01$) but not subsistence *versus* revenge and commercial *versus* revenge ($P > 0.05$). Regarding monkey meat consumption, the majority (67%) of the research participants declined to respond to this question. Nonetheless, 21% of the respondents gave hunger as the main reason while 5% attributed it to curiosity. Other reasons included revenge (3%), taste (2%) and cultural practices (2%) (Fig. 4). The difference across these was statistically significant ($P < 0.05$). Further analysis showed that the difference between hunting because of hunger compared to other reasons (taste, curiosity, revenge and culture) was statistically significant ($P < 0.001$). However, the differences between each of the other reasons (taste *versus* curiosity, taste *versus* revenge, taste *versus* cultural reasons, curiosity *versus* revenge, curiosity *versus* cultural reasons and revenge *versus* cultural reasons) were not statistically significant ($P > 0.05$).

Health problems associated with bush-meat consumption

Sixty-nine per cent of the respondents said they thoroughly cooked all the meat they consumed. Only a small number (19%) of respondents were aware of diseases which could be transmitted through handling and consumption of bush-meat. The health problems that were reported include diarrhoea (13%) and brucellosis (3.5%); the latter manifesting with swollen testes. The rest of the respondents (2.5%) who had claimed to be aware of health issues from consuming bush-meat could not specify the disease or the health problem.

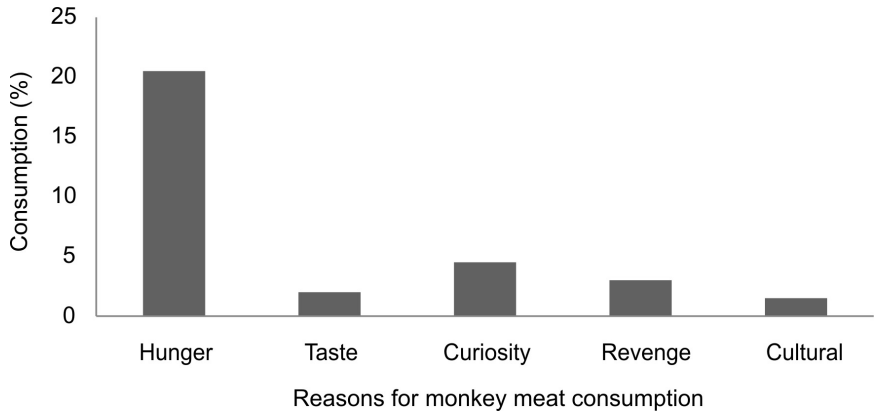

Fig. 4. Reasons for monkey meat consumption in the Nthongoni region.

Water and hygiene: a potential avenue for zoonosis transmission

Water sources were observed to be a potential mode for disease transmission as wildlife and livestock were observed to drink directly from the local rivers and streams, and some people fetched their domestic water from the same sources. Despite boreholes being reported as the main source of water by 52% of the respondents, uncovered wells and rivers/streams were also used by 31% and 6.5% of the respondents, respectively. Only 10.5% of the respondents had access to reticulated water. Utilization of the different water sources varied significantly ($H_{(3)}$ = 140.55, P < 0.0001). Rivers or streams, and most of the wells, were at a high risk of contamination, particularly from flood waters during the rainy seasons. On hygiene, the majority of respondents (95%) indicated that they washed their hands regularly, while 91% claimed to wash vegetables and fruits prior to consumption.

Qualitative data

Socioeconomic implications of the conflict

A source of poverty: 'Please get rid of these monkeys. They are the main cause of poverty in this area'. These were the words from one of the respondents who further reiterated that he stopped growing tomatoes (*Solanum lycopersicum*) and maize due to the destruction borne from wildlife. Some respondents wondered why they are not permitted to hunt for bush-meat yet wild animals destroyed their food crops all the time. They felt that their community had become poor as a result of the raids. 'We waste a lot of time guarding our crops. No other work can be done' said one farmer. The alternatives were to hire someone to patrol the farm, engage one's children in guarding, or give up farming altogether as expressed by another respondent: 'Baboons are the reason I don't raise any goats or chicken. I have no children, hence no one to protect the animals from baboons.'

During the PRA meeting, crop destruction, poverty and consequent hunger were cited as reasons for bush-meat hunting and the consumption of animals that died of unknown causes. Two respondents confessed to have eaten dead livestock although they claimed not to have experienced any adverse effects. It was also reported that some farmers resulted to charcoal burning and illegal harvesting and sale of poles and posts from the forest when their crops were destroyed.

Missing classes: Children have to guard the *'shambas'* (croplands) during the day, mainly from monkeys while the parents guard against elephants and other animals that crop-raid at night. The farmers observed that they might never harvest anything if this was not done. As a result, many school-going children missed classes until crops were harvested. Students were also said to get to school late or abscond from school altogether, for fear of attack by wild animals on their way to or from school.

Mitigation measures for crop raiding and livestock predation by wildlife

Electric fence

'How do we control these raids by wildlife?' This is a question that was frequently asked by farmers who expressed concern over movement of problem wild animals from the park to the village. It was observed that an electric fence had been erected but it only covered part of the park. Twenty-eight per cent of the respondents recommended extension of the electric fence to cover the entire park so as to prevent the animals from straying into their farms or homesteads.

Nonetheless, 36% of the farmers expressed that an electric fence was only a partially effective solution where non-human primates were concerned. One of them observed that: 'Monkeys are very clever. They find ways to cross through the electric fence'. The monkeys were also seemingly aware that the farmers could not chase them beyond the fence; hence they did not go far once they crossed the fence back into the park. They then followed the farmers back into the farms. Some farmers felt that the animals should be trapped and translocated. One farmer was particularly bitter at the monkeys for destroying her crops, and eating her chickens and goat kids. 'You should stop them from coming to our homes or else we will keep killing them' were her remarks. Elephants were also accused of destroying the electric fence by felling huge trees on it. These destructions, combined with the fact that some areas had not been fenced, allowed antelope, monkeys and elephants to continue destroying food crops. 'These animals are notorious for destroying pawpaw, pumpkins and other crops. Most of the times, we have to keep guard day and night'.

Poisoning/killing of crop pests

Revenge on the invading animals was a recurring issue in the course of the discussions.

Farmers were categorical that they would continue killing wildlife if no other solution was provided. They admitted using farm chemicals to poison the animals. One farmer observed that animals were more destructive during the dry season when even food for household subsistence was scarce: 'We kill those that come to raid at such times'. Another farmer gave an elaborate account of how and why they hunted elephants. He concluded by saying that elephants were very destructive: ' we have got to eliminate them if we are to harvest anything from our crops'.

Killing monkeys and hanging them on trees was also reported by the park managers. It was said that there is a belief in the community that hanging a skinned monkey on a tree scared other monkeys and hence prevented them from crop raiding.

Consumption of bush-meat

Questions associated with bush meat hunting or consumption provoked mixed reactions. Many respondents would not admit they hunted and/or consumed bush-meat, probably due to the illegal nature of the exercise. Nonetheless, a few respondents were candid about the issue and claimed that bush-meat was much tastier than livestock. Most of the respondents (66%) claimed they were unaware of any danger in consuming bush-meat. However, one respondent said that wild animals bore diseases since unlike livestock, they were not regularly vaccinated. Seven respondents also remarked that uninspected meat was dangerous, and that there were previous cases of people falling sick after eating bush-meat.

Participants during the PRA meeting concurred that people who had fallen ill due to bush-meat were hesitant to report to health authorities for fear of being prosecuted. Bush-meat is illegal in the country and most people who fell sick upon consumption would feign causes of their illness and report anything but bush-meat. Nevertheless, one of the key informants, a clinical officer, said she had handled many cases of diarrhoea, stomachache and headaches attributable to bush-meat consumption. Village elders and dispensaries were said to notify the veterinary office whenever such a problem was identified.

Monkey meat was also said to constitute bush-meat in the region but none of the respondents admitted to having personally eaten monkey meat. One respondent, however, narrated how her neighbour had died after eating monkey meat. She alleged he had eaten raw monkey liver in an attempt to treat himself of an unspecified disease. In the PRA meeting, some respondents confessed that they could have eaten monkey meat unknowingly from poachers who hawked bush-meat in the region: 'Strange meat is hawked around at night. The meat is a mixture of different wild animals and it's difficult to tell which animal the meat has come from'. Other respondents said they had heard of people eating monkeys but had never witnessed it.

Lack of compensation

Respondents claimed that wildlife authorities had failed to address reported crop raiding incidents. 'We are severely punished for hunting wild animals, yet nothing is done when they destroy our crops' said a farmer. They felt that crop raids and livestock predation by wildlife contributed to the high poverty levels in the area. Baboons and vervet monkeys were blamed for stealing food from houses and baboons in particular for breaking into granaries and poultry houses to steal food and eat chickens. The farmers recommended compensation for destroyed food crops and livestock killed by wildlife. They also expressed the need for compensation for the time spent guarding the farms from wild animals or for the money spent on hired guards.

Cultural beliefs

Cultural beliefs and values influence the way people live and behave. Some farmers had a belief that a baboon arm, if chopped, dried and used as a tool in planting, could increase crop yields. This prompted them to hunt down baboons. A community health worker observed that some members in the community believed that eating monkey fat could cure cancer amongst other diseases. Some people were therefore hunting baboons and Sykes monkeys to extract the fat. However, a section of the population considered eating monkey meat a taboo due to their close resemblance to humans and thus prohibition by Kamba culture. Due to stigma associated with monkey meat in the area, people who ate them did it in secrecy. They even shied away from seeking medication if they fell sick upon eating monkey meat.

DISCUSSION

The Nthongoni area is characterized by agro-pastoralism whereby maize, beans, cowpeas and sorghum cultivation are combined with livestock keeping. The area's proximity to Tsavo West and Chyulu Hills national parks often results in inadver-

tent interactions of humans and wildlife, often leading to conflict (Makindi, 2014). The majority of respondents in the current study reported experiencing crop raids, and livestock and poultry predation. Previous studies on human–wildlife conflict in India (Ogra, 2008; 2009), in other parts of Africa (Naughton, Rose & Treves, 1999; Tjaronda, 2007) and in Kenya (Njagi, 1995; Muruthi, 2005; Kioko *et al*., 2006a,b; Kivai, 2010) have similarly reported crop raids and livestock predation as serious sources of human–wildlife conflict. Due to intermittent seasons, often characterized by prolonged droughts, animals end up moving out of their designated habitats in search of food and water in human settlements (Njagi, 2011), hence exacerbating the conflict. In addition, crop raiding can be potentially driven by cultivation of food plants that are high quality nutritionally and more favourable to wild animals compared to the natural diets, especially during resource limiting periods (Chiyo, Cochrane, Naughton & Basuta, 2005; Strum, 2010; Hill, 2015). The animals reported to crop-raid in the current study included elephants, antelopes and baboons while livestock predation was blamed heavily on baboons and leopards. The human–wildlife conflict has significant socioeconomic and health consequences to Nthongoni community as discussed below.

According to IFAD (2007) indigenous communities are characterized by high rates of poverty and malnutrition in comparison to other members of the society. They experience low literacy levels and access to health services is limited. Preliminary surveys by Kivai (2008) in Nthongoni found that poverty was a key driving factor to unsustainable exploitation of wildlife and forest resources in the area and in the larger Chyulu ecosystem. Our findings reflect similar circumstances in the area, a situation that is further aggravated by extreme weather conditions which impacts heavily on farming; the main source of income. Most respondents earned less than 35 USD per month. Moreover, rain-fed agriculture was insufficient to provide adequate food for their households. Irrigation as a potential alternative to food production was not feasible in the area due to scarcity of reliable water sources. Thus, in an effort to meet basic household subsistence and income, the locals pursue other alternatives that are potentially anti-conservation and risky, such as bush-meat consumption, charcoal burning, encroachment into the parks for grazing, and harvesting of both wood and non-wood products for sale.

Moreover, even during the agriculturally good years, wildlife damage crops, strongly impairing household's ability to produce enough food for consumption, and for sale to meet other primary as well as secondary needs (Naughton *et al*., 1999; Ogra, 2008; Strum, 2010; Hiser, 2012). Furthermore, livestock predation by leopards, hyaenas and sometimes baboons in the case of small stock such as goats, sheep and poultry has considerable economic consequences on rural communities. Barua (2013) observed that loss of 10–15% of agricultural output in rural Africa may seem negligible at the national level but is highly costly to the affected individuals and families. On their part, Patterson, Kasiki, Selempo & Kays (2004) pinpointed loss of a cow as more detrimental to a farmer owning only one or two cows than it might be to someone with more animals. Besides loosing crops and livestock, communities living in close proximity to wildlife are often exposed to zoonotic diseases, physical injuries or even deaths resulting from attacks by large animals (Ladan, 2014; WWF SARPO, 2005). These challenges cause serious financial implications in the form of medical expenses and time spent away from work. Evidence from our study confirms the findings from these earlier studies. The majority of our respondents suffered enormous crop and livestock losses, as well as injuries and loss of human life to wildlife. These consequently led to a deterioration of their socioeconomic status.

Time spent guarding crops from wildlife are another economic cost of human–wildlife conflict (Hill, 2004; McLennan & Hockings, 2016). Crops must be guarded from animals such as elephants by night and baboons and birds by day. This pattern of wildlife crop raiding has been reported in previous studies and it is envisaged to emerge from the physical and behavioral characteristics of the raiding species (Naughton-Treves, 1997; Lee & Priston, 2005; Hiser, 2012). These studies indicate that large gregarious animals are perceived by farmers to be more destructive compared to small solitary species. The behavioral traits of the problem animals such as being diurnal or nocturnal influence the time of crop raiding or livestock predation. This frustrates the farmers' effort to guard the crops and livestock forcing them to engage in both day and night guarding. In the current study, one farmer highlighted how they wasted a lot of time guarding crops to the extent that little or no other work could be accomplished. This study also made an observation similar to one

made by Hoare (1992) and Barua (2013), on guarding responsibilities. The task of guarding crops at night was mostly done by men while children and sometimes women took the responsibility by day. In this regard, time that would have been probably spent on other productive activities was instead spent on guarding crops and livestock. The alternative was for a farmer to hire someone to patrol his crops or to give up farming altogether, as expressed in our results. Hiring a guard increased the costs of farming. Furthermore, Hoare (1992) and Kimega (2003) identified loss of sleep, living in fear and restrictions of movement as other social implications of human–wildlife conflict.

Huge crop losses due to wildlife raiding have been found to have adverse effects on human food security (Priston, 2009; Wallace & Hill, 2014). For instance, Kaswamila, Russell & McGibbon (2007) estimated that each year, wildlife in Tanzania destroyed on average food capable of feeding affected household for two months, and reduced annual household income by 1.3%. This can be worse where prevailing climatic conditions are not conducive for arable agriculture as is the case for Nthongoni. Findings from this study provide strong evidence that people in Nthongoni experienced considerable crop losses to destruction by wildlife especially primates and elephants. The majority of the people grew maize as the staple food. Interestingly, maize appears to be the most targeted crop by wildlife, hence implying that crop raiding in this area impacts heavily on food security. These observations mirror findings from other parts of Kenya, East Africa and Africa at large where farmers preference for maize growing and wildlife preference for it in raiding incidences was reported (Naughton-Treves, *et al.,* 1998; Hill, 2000; Webber, 2006; Warren, Buba & Ross, 2007; Kivai 2010; Strum, 2010; Guinness & Taylor, 2014). Primates, in particular and specifically baboons, have been reported as leading crop raiders in Laikipia and Tana River in Kenya (Kivai, 2010; Strum 2010), Kibale and Bundogo areas in Uganda (Naughto-Treves, 1997; Tweheyo, Hill & Obua, 2005), and in Selous in northern Tanzania (Gillingham & Lee, 2003). Similarly, baboons emerged as one of the most problematic animals implicated in both crop damage and livestock predation in the current study.

Withdrawing children from school to guard crops and livestock is likely to have a long-term adverse effect on the children's level and quality of education, and overall future quality of life for the individual households and the area at large. According to Mackenzie & Ahabyona (2012), crop guarding by school-going children have profound negative effects on their performance at school. In this study, respondents reported that children missed classes as a result of their involvement in guarding of crops from birds and monkeys. Moreover, children went to school late at times or stayed away from school altogether for fear of attack by wildlife. Besides children, attacks on their parents are also likely to have a negative impact on children's education. FAO (2009) and Barua (2013) observed that children of a parent who had been killed or maimed by wildlife participated in carrying out family chores and hence lost the opportunity to receive an education. Loss of crops and/or livestock to wildlife also had a huge economic impact that rendered farmers unable to support their children's education (Webber, 2006; Kaswamila *et al.*, 2007).

Significant health implications have been associated with hunting and slaughtering of wildlife for meat (Wolfe, Daszak, Kilpatrick & Burke, 2005). Hewlett & Hewlett (2008) largely blamed a 2002 outbreak of Ebola in Gabon and the Republic of Congo on game meat consumption. In the current study, hunting was reported as common, with the majority of the animals hunted being ungulates. One of the striking observations was that the only zoonoses that respondents associated with bushmeat consumption were diarrhoea and brucellosis. There are many zoonoses which can cause diarrhoea including gastrointestinal parasites. Brucellosis can also be transmitted through consumption of or contact with infected meat or through livestock that come into contact with infected wildlife, their infected foetuses or afterbirth (Cantas & Suer, 2014). Further studies should therefore be undertaken to determine the existence and epidemiology of zoonoses in the area.

Wildlife acts as potential reservoirs and transmission agents of disease causing pathogens to both humans and livestock (Kruse, Kirkemo & Handeland, 2004). Of the 1415 known human pathogens catalogued by Taylor, Latham & Woolhouse (2001), 62% were of zoonotic origin and new pathogens of same nature continue to emerge. However, different wildlife species are known to be key reservoirs of multiple disease-causing pathogens and hunters, guided by indigenous knowledge, avoid them. Primates, for instance, are such kind of species and even among

primates there are specific species that are believed to have higher potential of passing zoonotic infections than others. A previous study in Nthongoni revealed that hunters believed that vervet monkeys posed higher risk of zoonotic infections to the local people compared to baboons, Sykes monkeys and black and white colobus (*Colobus guereza*) (Kivai, 2008). Our current study also established that people felt more comfortable eating bush-meat from antelope as opposed to monkeys. However, as predicted by the optimal foraging theory in hunter gatherer societies (Smith, 1983): as the preferred prey species diminishes in numbers, the forager shifts to consumption of less preferred prey species, which in this case are the ones with higher risk of transmitting zoonoses. BCTF (2003) observed that whereas abundant species like dik-diks and common duikers (*Sylvicapra grimmia*) may be popular to hunt owing to their availability and ease of trapping, their numbers have declined, prompting hunters to shift to monkeys and other unpopular species. In this study, 12% of the respondents admitted that monkeys were hunted for meat in the area. This number could probably have been higher were it not for the stigma associated with monkey meat. Nevertheless, BCTF (2003) saw monkeys as a particular vector for zoonotic diseases owing to their genetic similarity to humans. Gao *et al.* (1999) implied that HIV/AIDS may have resulted from the transmission of chimpanzee (*Pan troglodytes*)-borne SIV (simian immunodeficiency virus) to humans, possibly through blood contact while killing and slaughtering wildlife.

As highlighted above, wildlife often cause death and injuries to humans and their livestock. Besides the direct attacks, people who guard crops and livestock from wildlife at night are exposed to other health problems such as pneumonia and malaria (WWF SARPO, 2005; Priston, 2009). In addition, vulnerability to attacks by dangerous nocturnal animals including poisonous snakes is potentially high during night guarding. Other health concerns observed in this study include sharing of water-points between humans and wildlife and utilization of common pasture grounds by wildlife and livestock. Similar instances were reported by Muma, *et al.* (2006) and Altizer, Bartel & Han (2011). In particular, Mbora & McPeek (2009) and Njagi (2011) clearly demonstrated how water points are a crucial interface of zoonotic disease exchange. Moreover, collection of fuel-wood, construction poles and posts, and vegetables from the forest was also observed. This was identified as a probable point of interaction with wildlife and an avenue of contact with wildlife faecal material; a situation that is likely to exacerbate the risks for zoonotic diseases.

Traditionally, communities adjacent to wildlife areas have derived their subsistence foods from wildlife. Today, bush-meat continues to form a major component of household meals amongst people living next to wildlife areas. In this study, two-thirds of respondents indicated hunting of wild animals for meat as common. Although they claimed wildlife hunting to be solely for subsistence, a few acknowledged it was also done for commercial purposes. This concurs with Pathan (2008), who observed that wildlife meat in Kenya has in the recent years evolved from subsistence to commercial. Worse still, efficient modern hunting technologies continue to phase out traditional traps, making hunting easier and more unsustainable.

Bush-meat consumption and trade is a major threat and driver of biodiversity loss. Many wild animals have disappeared from the world due to overexploitation for bush-meat (Wilkie, 2002; Vliet, 2011). Human–wildlife conflict worsens the situation particularly when afflicted farmers turn against wildlife and kill them in revenge. In Nthongoni, respondents admitted that farmers kill monkeys out of anger over destroyed crops and preyed livestock. The same has been demonstrated to have occurred in other communities locally (Ogada, Woodroffe, Oguge & Frank, 2003; Muruthi, 2005; Packer, Ikanda, Kissui & Kushnir, 2006), and in other parts of Africa (Government of Namibia, 2007). In particular, Else (1991) and Naughton-Treves, Treves & Wrangham (1998) reported that wild animals were being viewed as ecological dislocates whenever they raided crops, and thus treated as pests. In their study, Kivai (2010) found that people had a negative attitude towards conservation owing to the menace animals caused to their farms. As implied by respondents in the current study, farmers were especially aggrieved by lack of compensation for the destruction they faced from wildlife.

Muruthi (2005) observed that real culprits of the conflict: crop raids, livestock predation or human attack, were difficult to identify, hence the specific animals that were killed may not be necessarily the ones involved in the conflict. One informant in the present study disclosed the use of pesticides to poison the animals. Poisoning is non-selective and is likely to kill both targeted and non-targeted animals. Besides illegal killing by community mem-

bers, WWF (2007) asserted that wildlife authorities in Kenya, for instance, killed between 50 and 120 elephants each year for involvement in human–wildlife conflict.

The current study has also revealed that most villagers relied on firewood and charcoal for their cooking. They often utilized forests for fuel-wood when their farms could no longer afford them suitable and adequate materials. Charcoal burning was particularly reported to be on the increase, both for household use and for trade. Farmers claimed that it was the only way left for them to eke out a living after agricultural activities were hampered by crop raids and livestock predation. These activities lead to habitat fragmentation and the restriction of species into smaller habitable areas resulting to wildlife–wildlife conflict. Cases of unusual predation of species known to coexist without killing each other, have also been reported (Kivai, 2013). With an increasing human population, construction of roads and continued opening-up of areas that were earlier inaccessible (Inskip & Zimmermann, 2009), the trend is likely to worsen, triggering a vicious cycle of humans continuously destroying wildlife and their habitats, whereas, wildlife invaded community farms in search of food and water, when their natural habitats can no longer afford them enough.

CONCLUSION

Solutions aimed at ameliorating the cost accrued by both humans and wildlife in shared environments needs to be more aggressively incorporated into management decisions and strategies. Vliet (2011) observed that wild resources could be utilized sustainably to guarantee both human welfare and the long-term survival of the animals targeted for consumption. The UN (2010) report identified the need for a greatly expanded investment in sustainable ecosystem management, to reduce the vulnerability of the poor and to maximize the contribution of natural resources to rural development. It highlighted the need for poor people to secure rights on resource and other enabling conditions for poverty reduction. Moreover, it emphasized the need to ensure biodiversity protection measures respected indigenous peoples' traditional rights to forest-based livelihoods. Appearing to summarize these, Walker (2012) and Barua (2013) emphasized the need to increase economic benefits from wildlife by improving tourism, revenue sharing and wildlife-related employment.

This study concurs with the recommendations made above and highlights establishment of alternative means of livelihood for Nthongoni people as crucial. Furthermore, it recognizes the need to have the community involved in decision-making regarding wildlife management as well as wildlife resource harvesting and utilization. Consequently, the study recommends for the passing of policies and legislation that will mitigate the attacks and damages caused by wildlife, as well as for participatory research into other avenues that would afford the community a decent livelihood.

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