

Sokoine University of Agriculture



MSc Dissertation

**Community's Knowledge of the
Effects of Illegal Hunting and
Trade in Western Nyerere National
Park Tanzania**

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May 2024**

**COMMUNITY'S KNOWLEDGE OF THE EFFECTS OF ILLEGAL
HUNTING AND TRADE IN WESTERN NYERERE NATIONAL
PARK TANZANIA**

*Dissertation Submitted to Sokoine University of Agriculture in
Partial Fulfillment of the Requirements for the Degree of Master
of Science Wildlife Management and Conservation*

By

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EXTENDED ABSTRACT

Illegal bushmeat hunting is now a prominent problem in many regions of the world owing to the ecological, socioeconomic, and human health repercussions. In regions of Africa, particularly Tanzania, illicit bush-meat hunting and trading is responsible for a substantial drop in wildlife populations, a loss of government revenue, and employment opportunities, all of which cost conservation and expose people to zoonotic diseases. Despite the threats posed by illegal hunting activities, the phenomena are prevalent among individuals of the groups investigated. This calls our attention to assessing community understanding of illicit hunting activities and its consequences to conservation and public health. Specifically, this study aimed to (i) assess the knowledge of communities on the impacts of illegal bushmeat hunting and trade; (ii) assess the knowledge of communities on the potential health risks associated with handling and or consumption of wildlife products; and (iii) identify key species hunted for bushmeat and determine the spatial and temporal pattern of bushmeat hunting and trade. We employed key informant interviews and household surveys in eight (8) villages adjacent to the western part of Nyerere National Park. Generalized linear model (GLM) with Binomial error distribution was used to analyse the data. According to our results, a majority of local inhabitants recognise the impacts of illegal hunting, with around 84% realising that unregulated hunting may diminish wild species and negatively impact their socioeconomic livelihoods. More than half of the locals were unaware of the potential health risks associated with consuming and handling wildlife products. Our research also indicated that illegal hunting is more common during the rainy season than dry season. We found that, the spatial network of illegal bushmeat varies from origin site to destinations. Amongst the common hunted species, Hippopotamus (61%), Buffalo (56%) and Hartebeest (52%) are more vulnerable to illegal hunting. This study established the knowledge of the local communities towards the impacts of bushmeat hunting which is essential in developing

effective conservation and public health education programs. Nonetheless, our study emphasizes on specific and general anti-poaching strategies in curbing the illegal hunting in areas adjacent to protected areas.

IKISIRI KUU

Uwindaji haramu wa nyamapori sasa ni tatizo kubwa katika maeneo mengi ya dunia kutokana na athari za kiikolojia, kijamii na kiuchumi na afya ya binadamu. Katika mikoa ya Afrika, hasa Tanzania, uwindaji na biashara haramu ya nyama porini unasababisha kupungua kwa idadi ya wanyamapori, upotevu wa mapato ya serikali, na fursa za ajira, ambayo yote yanagharimu uhifadhi na kuwaweka watu kwenye magonjwa yanayoambukizwa kati ya wanyamapori na binadamu. Licha ya vitisho vinavyotokana na shughuli za uwindaji haramu, matukio hayo yameenea miongoni mwa watu wa vikundi vilivyochunguzwa. Hii inaelekeza umakini wetu katika kutathmini uelewa wa jamii wa shughuli za uwindaji haramu na matokeo yake kwa uhifadhi na afya ya jamii. Utafiti huu ulilenga (i) kutathmini uelewa wa jamii juu ya athari za uwindaji na biashara haramu ya nyamapori; (ii) kutathmini ujuzi wa jamii kuhusu hatari za kiafya zinazoweza kuhusishwa na matumizi ya bidhaa za wanyamapori; na (iii) kutambua spishi kuu zinazowindwa kwa ajili ya nyamapori na kubainisha maeneo na muda wa uwindaji na biashara ya nyama ya porini. Tulitumia mahojiano na watoa taarifa wakuu na tafiti za kaya katika vijiji vinane (8) vilivyo karibu na sehemu ya magharibi ya Hifadhi ya Taifa ya Nyerere. Muundo wa mstari wa jumla (GLM) wenye usambazaji wa hitilafu *Binomial* ulitumiwa kuchanganua data. Kulingana na matokeo yetu, wakazi wengi wa eneo hilo wanatambua athari za uwindaji haramu, huku takriban 84% wakitambua kuwa uwindaji usiodhibitiwa unaweza kupunguza wanyamapori na kuathiri vibaya maisha yao ya kijamii na kiuchumi. Zaidi ya nusu ya wenyeji hawakujua juu ya hatari za kiafya zinazoweza kuhusishwa na ulaji na utunzaji wa bidhaa za wanyamapori. Utafiti wetu pia ulionesha kuwa uwindaji haramu hutokea zaidi wakati wa mvua kuliko msimu wa kiangazi. Imeonekana kuwa, Viboko (61%), Nyati (56%) na Kongoni (52%) wako katika hatari zaidi ya uwindaji haramu. Utafiti wetu unasisitiza juu ya mikakati mahususi na ya jumla ya kukabiliana na ujangili

katika kukomesha uwindaji haramu katika maeneo yanayopakana
na maeneo ya hifadhi.

DECLARATION

I, **Yohani Rovetha Foya** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Yohani Rovetha Foya
(MSc. Candidate)

Date

The declaration above is confirmed by;

Prof. Alfani A. Rija
(Supervisor)

Date

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LIST OF MANUSCRIPTS

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Yohani R. Foya ^{a,*}, Charles P. Mgeni^{b,d}, Reuben M.J Kadigi^b, Michael H. Kimaro^{c,d}, Shombe N. Hassan^a **Do communities understand the impacts of unlawful bushmeat hunting and trade? Insights from villagers bordering Western Nyerere National Park Tanzania**

DEDICATION

This dissertation is dedicated to all conservationists around the world who have devoted their time and resources in conserving biodiversity.

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LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|--------------|--|
| AIC | Akaike Information Criterion |
| CBC | Community Based Conservation |
| CCS | Community Conservation Services |
| COSTECH | Commission of Science and Technology |
| DGO | District Game Officer |
| <i>et al</i> | and others |
| FAO | Food and Agriculture Organization of the United Republic of Tanzania |
| fig. | Figure |
| GELIFES | Groningen Institute for Evolutionary Life Sciences |
| GLM | Generalized Linear Model |
| IBHT | Illegal Bush-meat Hunting and Trade |
| ILUMA | Innovative Lead User Method Approach |
| KGCA | Kilombero Game Controlled Area |
| NNP | Nyerere National Park |
| SGR | Selous Game Reserve |
| <i>spp</i> | Species |
| SUA | Sokoine University of Agriculture |
| TANAPA | Tanzania National Parks |
| TAWA | Tanzania Wildlife Management Authority |
| TAWIRI | Wildlife Research Institute |
| TRADE | Trade Development and the Environment |
| UNEP | United Nations Environment Programme |
| URT | United Republic of Tanzania |
| VEO | Village Executive Officers |
| WCMC | World Conservation Monitoring Centre |
| WNNP | Western Nyerere National Park |
| X | Chi |
| > | Greater than |

CHAPTER ONE

1.0 Introduction

1.1 Background Information

The exploitation of wild animal species for consumption and trade has been linked to a dramatic decline in wild animal populations in most parts of the world (Ripple *et al.*, 2016), ranking illegal hunting among the major threats to biodiversity conservation worldwide (Azhar *et al.*, 2013; Rija *et al.*, 2020; Hohenlohe *et al.*, 2021). In addition to local and global extinction of wildlife species, illegal bushmeat hunting and trade (IBHT) is also linked with loss of revenue through legal tourism, loss of employment opportunities and increased conservation expenditure (Lindsey *et al.*, 2011; Rogan, 2015; Price, 2017). Nonetheless, the impacts of IBHT extend beyond ecological and socio-economic zones of conservation (Subramanian, 2013).

Several zoonotic diseases originating in wild animals are known to threaten people's lives and the global economy (FAO, 2018; Can, 2019; Rahman *et al.*, 2020). Of the 70% of zoonotic diseases known to infect humans, the majority originate from wild animals (Taylor *et al.*, 2001; Jones *et al.*, 2008). In parts of Africa, the illegal killing of wild animals for bush meat trade and/or consumption is prevalent among different communities (Luiselli *et al.*, 2019; Malik *et al.*, 2019; Bannor *et al.*, 2021; Torres *et al.*, 2021). Increased interaction of human with wild animal through illegal hunting and bush-meat trade are among other factors which increase risks of zoonotic transmission to human (Bird *et al.*, 2018; van Vliet *et al.*, 2017; Vandome and Vines, 2018; Thompson *et al.*, 2019). Most of zoonotic diseases with potential risks to human are common in tropical regions with diverse number of biological species (Han *et al.*, 2016; Allen *et al.*, 2017).

In Tanzania, the human risks for zoonosis are relevant as the country is among the mega-diversity country harbouring nearly

quarter of Africa's large mammals (URT, 2014). Different research studies in parts of Tanzania have evidenced the presence of pathogens with potential health risks which can be acquired through illegal bushmeat activities. Examples include; bovine tuberculosis (Cleaveland *et al.*, 2005; Clifford and Kazwala, 2013), Anthrax (Hampson *et al.*, 2011) and Rabies (Fooks *et al.*, 2012). Additionally, Katani *et al.* (2019) conducted a study in Serengeti and found several pathogens causing diseases to human from different samples of bushmeat. All these findings call for conservation and public health interventions to reduce the possible health risks to humans.

Although the country has implemented various conservation awareness programs, research studies indicate that illegal wildlife activities still exist in communities (Nielsen *et al.*, 2014; Kiffner *et al.*, 2015; Kideghesho, 2016; Rogan, 2017). Furthermore, research studies in northern parts of the country showed the perpetuation of different socio-cultural practises which increases the chances of zoonosis (Mwakapeje *et al.*, 2018; Ntirandekura *et al.*, 2018; Kiffner *et al.*, 2019). Persistence of illegal bushmeat activities and health risk practises in different communities draws our attention to conduct more studies to have an in depth understanding of peoples knowledge on conservation and public health issues. Again, to the best of our knowledge, the issue of zoonotic diseases is not well intergrated in most of the community education programs aimed to raise conservation awareness. This is despite the emphasize on multisectoral approach, to address issues related to zoonosis (URT, 2017; van Vliet, 2017; Kiffner *et al.*, 2019). Thus, this study aimed at assessing the knowledge of ecological, socio-economic and human health risks of people in eight villages bordering western Nyerere National Park (NNP). Recognizing the knowledge gap will enhance the formulation of suitable conservation measures towards reducing the IBHT and increasing public awareness on potential health risks associated with the activity.

1.2 Research Problem and Justification

The social, ecological, and economic impacts of bushmeat hunting and trade are relevant to most of the African countries rich in biodiversity, including Tanzania (Kideghesho, 2019). Several research studies in Tanzania found that the majority of local people engage in unlawful hunting for bushmeat for food and cash generating (Wilfred, 2013; Kiffner *et al.*, 2015; Nielsen *et al.*, 2014; Rogan, 2017). While offering alternatives for people's livelihoods, bushmeat hunting causes biodiversity loss, a reduction in revenues that might be earned from hunting and ecotourism, job loss, stock loss for legal supply of wildlife species, and higher patrol costs (Lindsey and Bento, 2012).

Beside causing threat to biodiversity, studies in Tanzania also indicated the potential health risks of bushmeat hunting to animals including human (Mwakapeje, 2018; Kiffner *et al.*, 2019). The persistence and flourishing of bushmeat hunting and trade signifies the need for undertaking further studies to reveal the understanding of people regarding the impacts of unlawful hunting to wildlife and community. To fill this knowledge gap and have an in-depth understanding of the impacts of the bushmeat hunting and trade in region of Tanzania, this study will assess the knowledge of local community on ecological and socio-economic impacts of illegal bushmeat hunting and trade. By doing so, the results of the study will help wildlife authorities in Tanzania to develop effective conservation and awareness strategies towards curbing bushmeat hunting and trade, and increasing public knowledge towards reducing the health risks associated with hunting and trade.

1.3 Main Objective

The main objective of this study was to investigate the understanding of people regarding the impacts of illegal bushmeat hunting and trade to conservation and public health.

1.3.1 Specific objectives

Specifically, the study aims at the following objectives:

- i. To identify species frequently hunted for bushmeat consumption and trade
- ii. To determine the spatial and temporal patterns of illegal bushmeat hunting and trade
- iii. To assess knowledge of local community of the potential health risks associated with handling and consuming bush meat
- iv. To assess the knowledge of the community on the impacts of unlawful hunting and trading of illegal bushmeat

1.3.2 Research questions

1. What are the most often exploited species for bushmeat consumption and trade?
2. What are the spatial and temporal patterns of illegal bushmeat hunting and trade activities?
3. Do the local people realize the likely health risks, ecological and socioeconomic impacts associated with illegal hunting activities?
4. How does the knowledge regarding the ecological and socio-economic impacts of illegal hunting vary in relation to the proximity to the park boundaries?

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CHAPTER TWO

2.0 Spatial Network and Seasonal Trend in Unauthorised Bushmeat Hunting in Western Nyerere National Park, Tanzania

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Abstract

Unauthorized bushmeat hunting is risking several wildlife species' survival in Africa. Identifying the hunting and trading networks of such illegal activity and seasonal patterns is among other strategies for developing an effective conservation countermeasure. In this regard, we conducted semi-structured interview to explore information from 62 reformed poachers and eleven conservation officials in western Nyerere National Park to reveal the following: (i) hunting and trading areas for illegal bushmeat; (ii) routes taken by poachers to enter and leave the protected area; (iii) temporal trends of illegal bushmeat hunting and trade; and (iv) species that are more vulnerable to illegal hunting. Our results indicate that illegal hunting occurs both within and outside western Nyerere National Park while the bushmeat trade is mostly operated within the villages. Also, we revealed that poachers purposely alternate routes while exiting the

park. It appeared that poachers mostly preferred large-sized species, including Hippopotamus Buffalo, and Hartebeest. Additionally, we found that the trend for illegal hunting and bushmeat trade is comparatively higher (74%) during the wet season than the dry season. Overall, our results suggest the need to strengthen measures to control unauthorised hunting in the area to facilitate effective anti-poaching patrols during the rainy season. All these measures, among others, could help halt illegal bushmeat activities.

Key words: Illegal bushmeat, spatial network, seasonal trend, poachers

2.1 Introduction

Unauthorised bushmeat hunting and trade is among the common practices threatening biodiversity conservation in many parts of the world (Tilker *et al.*, 2019; Esmail *et al.*, 2020; Vijeta *et al.*, 2021) as it is linked to extinction of wildlife species (Ripple *et al.*, 2016; Loveridge *et al.*, 2020) and impedes conservation efforts (van Velden *et al.*, 2020; Lindsey *et al.*, 2012; Erena *et al.*, 2020). The killing of wild animals for bushmeat and trade does not only jeopardize the survival of wildlife creatures and poses challenges to conservation authorities, but it also has a negative impact on people's livelihoods (Twinamatsiko *et al.*, 2014; Rogan, 2015; Price, 2017; Vandome and Vines, 2018; Kideghesho, 2019).

According to literature (Soaga, 2014; Abere *et al.*, 2016; Ordaz-Németh *et al.*, 2017; Souto *et al.*, 2019; Sharma *et al.*, 2020) the illegal wildlife offtake for consumption and trade is related to various socio-economic factors such as income status, education, age, gender. Again, Lindsey *et al.* (2012) argues that bushmeat hunting and trade are geared by increased demand for bushmeat, unemployment, and ineffective law enforcement. Furthermore, other researchers linked the unlawful exploitation of wild animals with behavioral perception and traditional beliefs (Morsello *et al.*, 2015; Chausson *et al.*, 2019).

Considering different factors which fuel the illegal offtake of wild animals, researchers proposed a number of strategies for lowering illicit bushmeat activities. Implementing community conservation programs, for example, to raise conservation awareness and support community development projects (Mfunda and Roskaft, 2010; Lichtenfeld, 2019; Kideghesho, 2019), providing alternative means of obtaining protein and income (Rentsch and Damon, 2013; Rogan, 2015), establishing and targeting conservation efforts to a specific demographic group of wildlife offenders (Kideghesho, 2019), and changing people's attitudes toward bushmeat preference (van Velden *et al.*, 2018; Chausson *et al.*, 2019; Nilsson *et al.*, 2020), as well as improving law enforcement including anti-poaching patrol (Hilborn *et al.*, 2006; Bitanyi *et al.*, 2012; Lindsey *et al.*, 2011).

Concurrently, there are well-documented and extensive concerns about revealing the spatial and temporal distribution of illegal wildlife activities as a countermeasure to facilitate effective anti-poaching patrols (Critchlow *et al.*, 2015; Faulkner *et al.*, 2018; Moore *et al.*, 2018). In Tanzania, several research studies provided basic information regarding the areas that are prone to poaching as well as temporal patterns of illegal wildlife activities (Martin *et al.*, 2012; Knapp *et al.*, 2017; Kyando *et al.*, 2017; Rija, 2017). Furthermore, similar studies indicate the managerial implications associated with spatial-temporal patterns of illegal wildlife activities (Lindsey *et al.*, 2011; Mackenzie *et al.*, 2011; Maingi *et al.*, 2012; Sanchez-Mercado *et al.*, 2016; Moore *et al.*, 2018). Unfortunately, there is scarce information concerning the illegal hunting operations in large parts of Tanzania as most research on illegal wildlife activities are biased towards the Serengeti national park (Wilfred, 2013; Ceppi and Nielsen *et al.*, 2014).

To fill knowledge gaps, this study investigated poachers' knowledge and experience with illegal hunting and the spatial-temporal patterns of bushmeat hunting and trade in the western sector of Nyerere

national park (WNNP). Specifically, the study aims to answer the following questions: (i) Which species are more vulnerable to illicit bushmeat hunting and trade? (ii) What is the spatial pattern of illegal bushmeat hunting and trade activities? (iv) Does illicit bushmeat hunting and trading vary seasonally? The findings of this study will contribute towards developing specific and general mitigation measures to curtail the illicit bushmeat network.

2.2 Materials and Method

2.2.1 Study area

The study was carried out in Nyerere National Park. Located between 7.5°S to 10.5°S, and 36.0°E to 38.7°E (Fig. 2.1) the park forms the part of Selous-Mikumi ecosystem and it is recently the largest national park in Africa (30, 893 km²). The NNP is endowed with diverse and significant population of wild animal species *inter-alia*; African bush elephant *Loxodonta africana*, African Cape buffalo *Syncerus caffer*, Hippopotamus *Hippopotamus amphibius*, Impala *Aepyceros melampus*, Lichtenstein's hartebeest *Alcelaphus buselaphus lichtensteini*, Sable antelope *Hippotragus niger*, Eland *Taurotragus oryx*, Waterbuck *Kobus ellipsiprymnus* and several other species including birds and herbivore predators (TAWIRI, 2019). The area is exclusively inhabited by miombo woodland although other different types of vegetation including forests, dense thickets, and riverine swamps exist (Baldus and Hahn, 2009).

Specifically, the present research study was conducted in eight villages bordering the western part of the park, Ilonga, hereafter known as the western Nyerere National Park (WNNP). Administratively, the WNNP is bordered by the Iluma Wildlife Management Area (IWMA), Open Areas (OAs) and Kilombero Game Controlled Area (KGCA) the protected area recently gazetted as Game Reserve (URT, 2023). Apart from agricultural production of paddy, maize, green gram and sesame it has been noted that people in the study area also participate in illegal mining and hunting for consumption and trade. To achieve the study's objectives, the

villages were chosen based on the prevalence of poaching activities and proximity to park boundaries. In terms of species frequently hunted for bushmeat, we classified large-sized animals as those weighing more than 50 kg (Kingdon, 2016), whereas the most vulnerable species to bushmeat hunting were those with a frequency equal to or more than 50%.

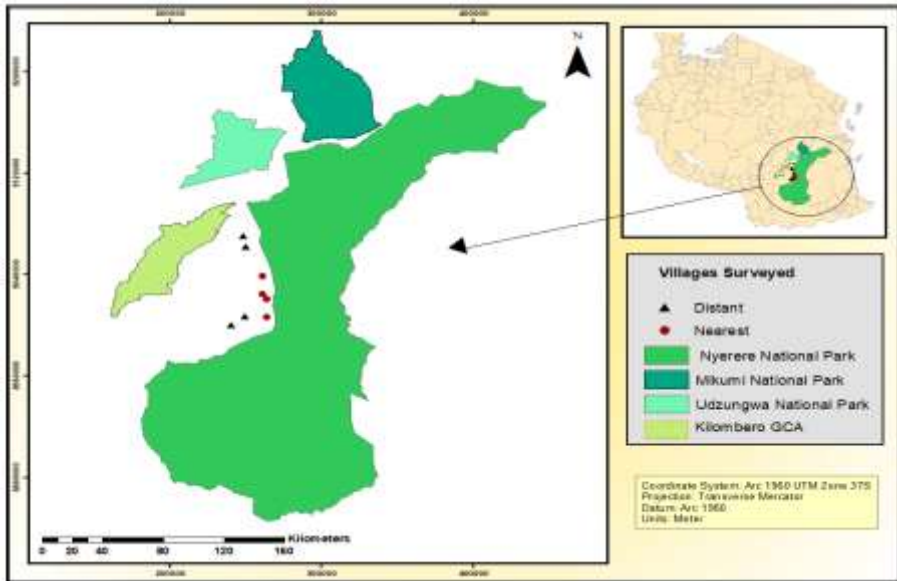


Figure 2.1: A map showing Nyerere National Park and the adjacent villages where this study was conducted. The red circles represent close villages ($\leq 15\text{km}$) and the black triangles represents the far villages ($>15\text{km}$) from the park boundaries.

2.2.2 Data collection

We conducted semi-structured interview for the period of three months (January-March 2020) to collect data from key informants, including 62 retired poachers and eleven protected area officials. We targeted poachers as they possess detailed information regarding unauthorized hunting practices. The first respondent (a reformed poacher, hereafter referred to as "poacher") was purposely

selected after preliminary discussion with conservation personnel of the study area. We then reached other poachers through snowball sampling. We used a widely spoken local Swahili language, and respondents were assured of anonymity and confidentiality through informed consent. We obtained informed consent from all participants and anonymized their names and villages to ensure that they could not be tracked or implicated in any way.

We gathered basic socio-demographic information, such as age, gender, origin (indigenous or immigrant), and time of residency, before posing sensitive questions concerning unlawful hunting. Using questions from our interview guide, we asked poachers key questions to explore information regarding the species commonly harvested for bushmeat; hunting and trading networks for bushmeat and hunting season (wet/dry/both). To complement information provided by poachers, we then conducted an in-depth interview with conservation officials who were involved in executing anti-poaching operations in the study area. The majority of conservation staff interviewed were from prior authorities (TAWA) who managed the area before TANAPA took responsibility once it was proclaimed a national park in late 2019.

2.2.3 Data analysis

Prior to data analysis, we coded key replies from respondents that addressed our research questions. Responses were presented using descriptive statistics in the form of frequencies, percentages, and charts. We then conducted an inferential statistical analysis for all data using R Core Team, 2021. A Generalized linear model (GLM) with Poisson error distribution was used to assess the origin of bushmeat (whether within, outside or both within and outside WNNP), routes taken to enter or leave the hunting site (whether same, different or both), the destination for bushmeat and seasonal trend (wet, dry or both). The significance threshold was fixed at $P \leq 0.05$.

2.3.4 Spatial pattern of hunting and trade

2.3.4.1 Origin of bushmeat

The origin of bushmeat statistically significantly varied (GLM, Deviance = 47.698, df = 2, P = 0.001, Fig. 2.2) in which nearly 60% of poachers reported bushmeat to originate from both inside and outside WNNP while 35% claimed to solely hunt within Nyerere national park. The hunting areas identified by poachers include those within buffer zones, adjacent to the park, close to farm fields, open areas and within Iluma WMA and Kilombero Game reserve area. Additionally, while inside the protected areas, the poachers reported establishing their camps close to water points, under tall trees with cover to prevent being detected. They argued that tree cover prevents the emission of smoke while they are cooking.

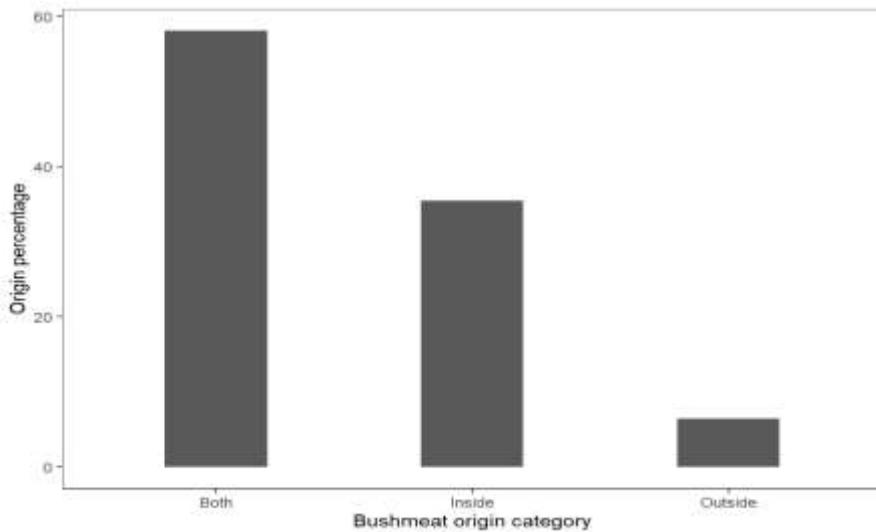


Figure 2.2: Poachers' response regarding where illegal bushmeat hunting is practiced

2.3.4.2 Routes taken to enter and leave WNNP

There was a statistically significant difference in the routes used by poachers to exit the hunting sites (GLM, Deviance = 29.546, df = 2, P=0.001) with approximately 60% of poachers frequently using similar or different routes to leave the hunting sites, while 22% use different exit routes and 18% use similar routes (Fig. 2.3).

Comparisons of routes used by poachers revealed that poachers that use diverse routes to leave hunting grounds were significantly lower than those using the same routes and different routes interchangeably (GLM, $Z = -3.934$, $P < 0.001$). Furthermore, poachers who exited hunting areas through the same path were much fewer than those who used the same and alternative routes interchangeably (GLM, $Z = -4.486$, $P < 0.001$). Poachers who claimed to take the same routes while leaving the hunting location reported that they generally choose routes that are not often monitored since they are difficult for rangers to reach. Meanwhile, several poachers reported choosing different routes when they got suspicious that they were being pursued by patrol rangers.

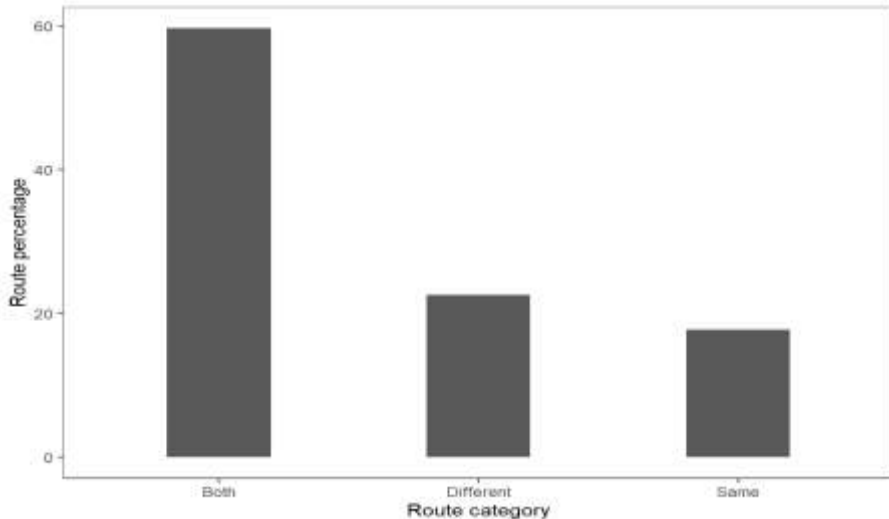


Figure 2.3: Poachers' responses indicating the routes used to enter and exit the protected area.

2.3.4.3 Destination of bushmeat

There was a statistically significant difference between locations where bushmeat is taken for consumption and trade (GLM, Deviance = 32.9 df = 2, $P < 0.001$). A greater number (66%) of respondents stated that they sold bushmeat within their village land, whereas 21% sold bushmeat both within and outside their village land, and only 13% sold bushmeat outside their village territory (Fig.

2.4). Poachers who indicated that the bushmeat trade was largely performed within communities argued that selling outside the village is riskier due to enhanced security and a larger number of individuals, the majority of whom are unknown. Furthermore, the majority of poachers (73%) stated that after hunting wild animals for bushmeat, they transport it to specific houses that serve as distribution points, whereas another group of poachers (27%) stated that they transport bushmeat to specific agents (hereafter traders) who distribute bushmeat to other consumers. Poachers reported that their family members, close relatives, and acquaintances are among the other consumers. Moreover, the interviewed poachers stated that they engage young unemployed males to sell bushmeat and distribute it to their customers. Furthermore, poachers claimed to use mobile phones to notify their agents and customers.

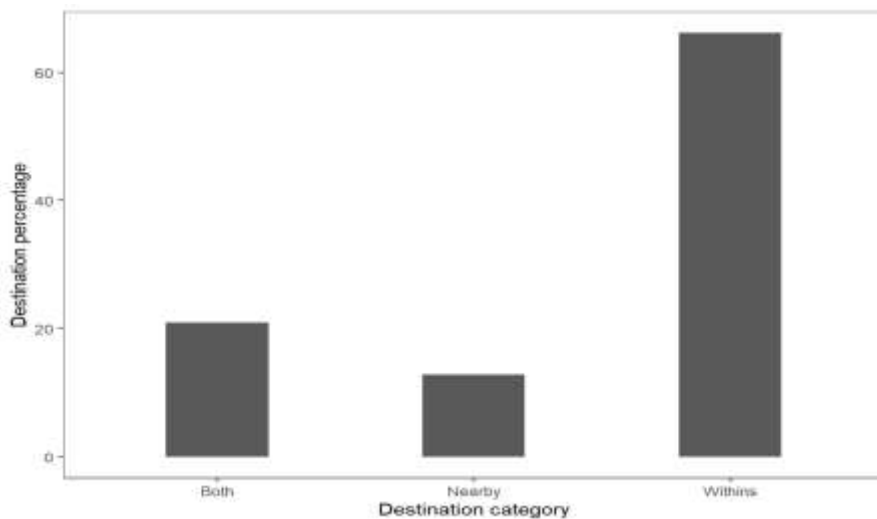


Figure 2.4: Reported percentage of destinations where illegal bushmeat is taken for trade. Both, nearby and within, represents destination responses when poachers were asked where bushmeat is taken for trade.

2.3.5 Temporal pattern of illegal hunting and bushmeat trade

There was a statistically significant variation in seasonal patterns of bushmeat hunting and trading (GLM, Deviance = 71.373, DF = 2, P 0.001), with around 74% of poachers engaging in hunting activities during the rainy season (Fig. 2.5). Interviewed poachers said that hunting during the rainy season is preferable owing to: low patrol/security (heavy rainfall, rivers overflow and become difficult to cross; roads are slippery (mud soil) for patrol cars; absence of tourist hunting companies who regularly patrol their area in early dry season), strong demand for bushmeat (supported by religious ceremonies-Christmas, Easter, Baptism), animals are widely spread (some animals come near to village land), presence of crops in farmlands attracts animals close to villages land, presence of crops in farmlands attracts animals. The authorities interviewed admitted that they had difficulty conducting anti-poaching patrols during the wet season since the park features a variety of tiny seasonal and big permanent rivers that flood during the rainy season. The interviewed officials confessed that; they experience difficulties in conducting anti-poaching patrols during the wet season as the park has a number of small seasonal and large permanent rivers which overflow during the rainy season. Some of the rivers noted as troublesome during the rainy season were the Mnywamaji, Msakamba, Mwatisi, Namhanga, Muambata, Luhea, Luwegu, and Muegea.

2.3.6 Species frequently hunted for bushmeat trade and consumption

According to our interviewed poachers, the most commonly hunted species for bushmeat are; Hippopotamus *Hippopotamus amphibious* (61%), Buffalo *Syncerus caffer caffer* (56%), and Hartebeest *Alcelaphus buselaphus lichtensteinii* (52%), Impala *Aepyceros melampus* (45%), Waterbuck *Kobus ellipsiprymus* (19%), Bushbuck *Tragelaphus scriptus* (18%), Puku (15%), Dikdik *Madoqua Kirkii* (15%), Bushpig *Potamochoerus larvatus* (10%), Warthog (11%), Cane rat *Thyryonomys spp* (8%) and Eland (6%). Regarding

the IUCN Red List of Endangered species, Hippopotamus *Hippopotamus amphibious* and Puku *Kobus vardonii* were categorized as Vulnerable (VU) and Near-threatened (NT) respectively, while the other ten species were under the Low Concern (LC) category. Overall, the majority (10) of the 12 identified species were classified as Least Concern (LC).

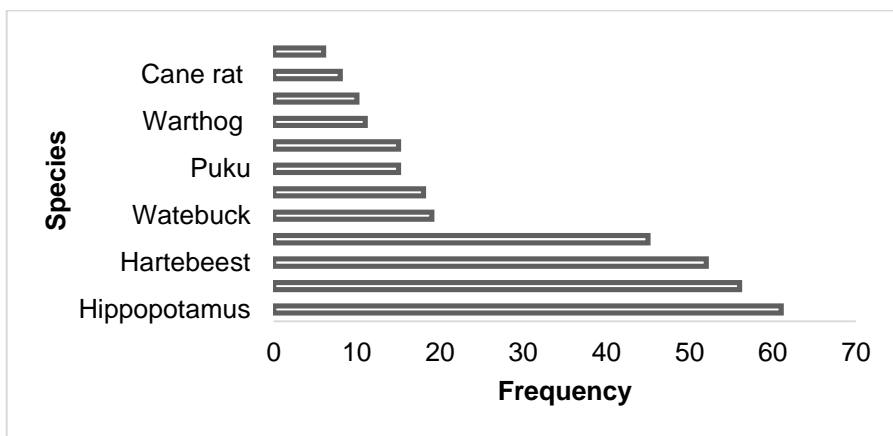


Figure 2.5: List of wild animals frequently hunted. The most targeted species were categorized as large-sized mammals (> 50 kg), comprising species with a 52% frequency (representing at least half of the respondents), which were Hippopotamus, Buffalo, and Hartebeest.

2.4 Discussion

Our study demonstrated the spatial and seasonal variation in unauthorized bushmeat hunting activities within and surrounding areas of WNNP. We revealed that unlawful bushmeat hunting happens both within and outside of WNNP due to the dispersion of wild animals and availability of other forms of protected areas including Kilombero Game Reserve, Iluma WMAs and other open areas with wildlife. This suggests that bushmeat hunting is not restricted to the limits of the WNNP. Under such circumstances it is

essential to increase anti-poaching operations in areas with poaching incidences (Bitanyi *et al.*, 2012; 't Sas-Rolfes, *et al.*, 2019). However, in light with our findings, anti-poaching patrols should be expanded to include regions both within and outside the park.

In the cause of luring patrol rangers, we found that the poachers developed a mechanism of alternating their routes while leaving the hunting grounds. This result aligns with other studies which suggest that wildlife criminals employ varied tactics to avoid detection in their illicit activities (Rija and Kideghesho, 2020). According to anti-poaching personnel, patrol rangers use different techniques including waiting poachers at entry points. It can be argued that, flexibility in the exit route indicates that poachers were aware of the rangers' techniques, thus they used different departure routes to avoid being ambushed. Furthermore, the consistent use of the same entry and exit routes by the poachers may imply the existence of alternative routes unknown to the rangers, or it might indicate that the poachers know where the patrol rangers are located. In essence, our findings reflect what has been documented in other literature that the pathway network for wildlife offenders is always diverse and ambiguous (Latinne *et al.*, 2020; Duffy, 2016).

The present research revealed that the majority of illicit bushmeat reaches residents within the village. We also found that many poachers adopt a "specificity strategy", where a relationship between the poacher and the distributor or buyer is pivotal to their operations. Similar commercial patterns in bushmeat trade have been reported by researchers such as Knapp *et al.* (2017), Smiley *et al.* (2019), and Andimile *et al.* (2021) in different locations. In addition, we found we revealed that poachers transport bushmeat to a specific residence, functioning as a central distribution hub prior to distribution of bushmeat to close relatives, family members and friends. One of the poachers was quoted saying that "*It is currently not possible to trust everybody because of the large number of immigrants in the neighbourhood is high, so, it is impossible to*

determine who is who, also, some indigenous people are untrustworthy since they may collude with anti-poaching officials." This implies that poachers are hesitant to sell bushmeat in open areas because they are less likely to be apprehended by wildlife law enforcement. Moreover, this finding implies that poachers do not sell their bushmeat to just anybody, but preferably to persons who cannot reveal their identities. As per our discussion with wildlife personnel in the study area, amongst wildlife law enforcers employed between 2013 and 2015 to aid forces in combating poaching, fifty-six rangers (56) and eight wildlife officers (8) were allocated to Ilonga Sector, which was the administrative point. This might have increased the manpower dedicated to anti-poaching patrols, restricting the poachers' capacity to operate widely. Continuous anti-poaching patrols in zones with persistent illegal wildlife activities are widely recognized as effective in managing such unlawful actions (Moore *et al.*, 2018; Cooney *et al.*, 2017).

Our study found that the tendency for unlawful bushmeat operations in WNNP is higher during the rainy season than during the dry season. A similar pattern has been found in the regions surrounding Ugalla Game Reserve (Wilfred *et al.*, 2017). However, our findings contradict those of previous research investigations. For example, Knapp *et al.* (2017) reported a high percentage of illegal hunting throughout the year in Ruaha National Park, but study in the western Serengeti National Park (Holmern *et al.*, 2007) showed a greater rate of illegal hunting during the dry season. The varying pattern of illegal hunting activities in our study area indicates the necessity for improved anti-poaching and management initiatives. Based on study participants, unauthorised bushmeat hunting and trading is common during the wet season since there is a strong demand for bushmeat (associated by religious festivities such as Christmas, Easter, and Baptism), and it is also easier to access the park and wild animals. This indicates the need to intensify and strengthen antipoaching patrols during the religious and other customary rituals.

Our study revealed that poachers target large-sized herbivore mammals' such as hippopotamus, buffalo, and hartebeest during illegal hunting. Although present outside WNNP, one species, *Kobus vardonii*, is designated as Near Threatened (NT), and *Hippopotamus amphibius* is listed as Vulnerable (IUCN, 2021). Although hunters are known to be indiscriminate species during hunting (Lindsey *et al.*, 2011), our findings show that larger species are more vulnerable to unlawful bushmeat hunting than smaller species. Poachers in our study area stated that large-sized animals may be easily accessed inside and outside WNNP during the rainy season and generate a great quantity of meat, resulting in a large profit when sold. The observation that larger species are more targeted to illicit bushmeat hunting aligns with other studies showing a decline in the populations of large mammals (Ziembicki *et al.*, 2013; Rogan *et al.*, 2017; Rija *et al.*, 2020). Furthermore, the fact that the majority of the species recorded in our study area were classified as Least Concern should not be misunderstood, as the category does not mean that their rate of exploitation is low (see Souto *et al.*, 2019). Hence, it is critical to ensure that conservation efforts are directed at protecting species from all categories, as even LC are more likely to become extinct in the long term.

2.5 Conclusions and Recommendations

2.5.1 Conclusions

Our findings revealed that bushmeat hunting and trafficking in the vicinity of WNNP occur in a complex spatial network, including local people inside village areas. Furthermore, we showed that the illegal harvesting of bushmeat is more prevalent during the rainy season. Hippos, buffalo, and hartebeest are the most often hunted animals for bushmeat. Overall, our findings suggest that enhancing anti-poaching patrols within the WNNP and covert operations outside the area might be among other measures for reducing unlawful hunting.

2.5.2 Recommendations

There is a need to expand anti-poaching activities in the area. To demoralize the bushmeat supply, the anti-poaching force should perform special patrol missions, especially during religious or cultural festivals. In addition, there should be frequent patrol inspections in agricultural fields and other places where animals are more prone to pass, dwell, or shift due to seasonal migration. Furthermore, the intelligence unit must improve monitoring in the village to search for and acquire information on people who are planning to engage in unlawful hunting.

We recommend for the construction of basic bridges, particularly on often overflowing seasonal rivers. Along with bridge construction, regular road maintenance such as grading is necessary. This will improve anti-poaching patrols throughout the year since patrol rangers will have easy access to wide areas of the region.

It has been observed that the WNNP is bordered by other types of protected areas, which facilitate illicit bushmeat hunting and trafficking among locals in the examined villages. In this case, we advocate a collaborative management patrol between WNNP, KGCA and Iluma WMA to enable information exchange and experience. Because poachers utilize both sites interchangeably as hunting grounds, the joint patrol might serve to increase anti-poaching patrol and discover criminal networks in both places.

We recommend for the management authority of WNNP to involve local communities in the decision-making process regarding different conservation programs as they are crucial for long – term success of conservation initiatives.

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Author contributions

YRF designed and conducted the study and developed the manuscript; SNH guided the development of the research proposal, executed the field work and reviewed the manuscript; RTJK and CPM reviewed the manuscript; and MHK helped with statistical data analysis.

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CHAPTER THREE

3.0 The Knowledge About the Potential Health Risks of Illegal Bushmeat Activities Among Local Communities Adjacent to Western Nyerere National Park, Tanzania

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Abstract

Establishing knowledge of local communities regarding the potential health risks of illegal bushmeat hunting and its related practices is among the essential means to developing effective conservation and public health programs. To reveal the understanding of the local people regarding the potential health risks of bushmeat consumption and handling of wildlife products, we used a semi-structured questionnaire to survey 261 households in eight villages located adjacent to the western part of Nyerere National Park. Also, we interviewed eight key informants, including conservation personnel and livestock officers, in the study area. The proportion of local

people who were unaware that handling of wildlife products and bushmeat consumption were risky behaviours towards acquiring zoonotic diseases was slightly higher (57%) than the proportion of respondents who were aware of the likely risks of zoonotic diseases from the practices. After all, the majority (83%) of local people admitted having come into contact with wildlife products, while over 70% reported to have consumed bushmeat. We found that local communities living closer to the park boundaries (<15 km) have a higher likelihood of contacting wildlife products, and that community members who have lived in the area for more than ten years have experienced more contact with wildlife products than immigrants. Moreover, the age of inhabitants and length of stay were found to be the most significant factors in determining the likelihood of bushmeat consumption. Most people seemed to prefer bushmeat to domestic meat, arguing that bushmeat is far more flavorful, tender, not tainted with chemicals, and has less fat, making it safer. Our study demonstrated that local communities participate in risky practices without contemplating the health consequences that could emerge should a zoonotic disease outbreak occur. Among other strategies, we recommended conservation and public health institutions to increase awareness campaigns on the possible health risks of zoonotic diseases associated with wildlife.

Keywords: local communities, bushmeat consumption, wildlife products, zoonotic diseases, awareness

3.1 Introduction

The consequences of illegal bushmeat hunting and trade extend beyond the ecological and socioeconomic zones of biodiversity conservation (Lawson and Vines, 2014), and it has been well documented that increased human interaction with wild animals through illegal hunting and bushmeat trade is one of the factors that increases the risks of zoonotic transmission to humans (van Vliet *et al.*, 2017; Vandome and Vines, 2018). While diseases prevalence is more likely in tropical locations with rich biodiversity (Han *et al.*,

2016; Allen *et al.*, 2017), the socioeconomic effects are far-reaching. Wildlife-borne zoonotic infections are known to threaten health of the public as well as the economy on a local and worldwide scale (Sherikar and Waskar, 2005; FAO, 2018; Can *et al.*, 2019).

In Tanzania, the potential health risks due to pathogenic diseases derived from wildlife are as relevant as in other parts of the world (URT, 2017). This is justified by the substantial number of studies in parts of the country that indicate the presence of pathogens derived from wildlife products, including bushmeat (Clifford and Kazwala, 2013; Hampson *et al.*, 2011; Fooks *et al.*, 2012). The possibilities of contacting zoonosis are further evidenced by continuous social and cultural behaviours that are also connected to zoonosis (Mwakapeje *et al.*, 2018; Ntirandekura *et al.*, 2018; Mtui-Malamsha *et al.*, 2019). Yet, most of the local communities still engage in unlawful bushmeat hunting, without realizing that such practices may increase the chances of contacting zoonosis (van Vliet *et al.*, 2017; Schilling *et al.*, 2020)

So far, various studies have acknowledged the issue of zoonosis and call for research study to explore the knowledge of local people about diseases linked to wildlife (Wolfe *et al.*, 2005; Katani *et al.*, 2019). It has been shown that understanding people's knowledge is critical for developing effective measures to limit the spread of zoonosis (Subramanian, 2013). Moreover, Kiffner *et al.* (2019) and Kriegel *et al.* (2021) emphasized that the knowledge gap should also include socio-demographic characteristics as it is essential to know the area of concentration during the design of an awareness program. While the anticipated health consequences connected with illicit bushmeat have been recorded (Narat *et al.*, 2018; Keatts *et al.*, 2021), data on people's understanding of zoonotic diseases is sparse among community members adjacent to Nyerere National Park, Tanzania.

Therefore, the present study assessed the knowledge of zoonosis from local communities bordering the western part of the Nyerere National Park (WNNP). We anticipated that the findings of this study will contribute towards developing the conservation and public health interventions to address the issues of zoonosis as well as reducing the negative impacts associated with illegal bushmeat hunting and trade. Specifically, the study assessed (i) the knowledge of local communities regarding the zoonotic diseases originating from wild animals (ii) the extent to which local communities consume bushmeat and/or contact with wildlife products (iii) the preference behavior towards bushmeat consumption (iv) the demographic and spatial factors influencing variation of local communities' responses concerning the activities related to handling of wildlife products and bushmeat consumption.

3.2 Materials and Method

3.2.1 Study area

Nyerere National Park (NNP) is located between 7.75° and 10.5°S and between 36.0° and 38.7°E (Fig. 3.1). The park was formed after the Selous Game Reserve (SGR) was divided into two parts, one part retaining the name of SGR while the second largest part was re-named "Nyerere National Park". Administratively, the park is bordered by Mikumi National and Udzungwa Mountains National Parks, Kilombero Game Controlled Area (KGCA), wildlife management areas, and open areas (TAWIRI, 2019). The NNP is currently the largest national park in Africa with an area of 30,893 km² (URT, 2019) and holds a variety of wild animal species in comparatively large numbers, such as the African Savanna elephant (*Loxodonta africana*), African Cape buffalo (*Syncerus caffer*), Hippopotamus (*Hippopotamus amphibius*), a variety of antelopes, an endangered African wild dog (*Lycaon pictus*) and several other predators (Baldus and Hahn, 2009). The area consists of extensive miombo woodland dominated by *Brachystegia spp*, *Julbernardia spp*, *Isoberlinia spp*, *Azelia quanzensis* and *Pterocarpus angolensis*.

This study was conducted in eight villages around the western part of the park, henceforth referred to as Western Nyerere National Park (WNNP). The selected study villages are located within the Ulunga District and border other protected areas including Iluma Wildlife Management Area and Kilombero Game-Controlled Area. The area consists of multi-ethnic groups with the Pogoro tribe being the major ethnic group. The ecosystem encompassing the study area also has historic records of diseases affecting both humans and wild animals such as *Anthrax* (Gainer, 1987; Mwakapeje *et al.*, 2018). The villages were purposively selected based on their proximity (close/far) to Nyerere National Park and occurrences of illegal bushmeat activities. The names of villages were anonymized to ensure that respondents remain unknown as information was gathered on the basis of illegal bushmeat practices in the area.

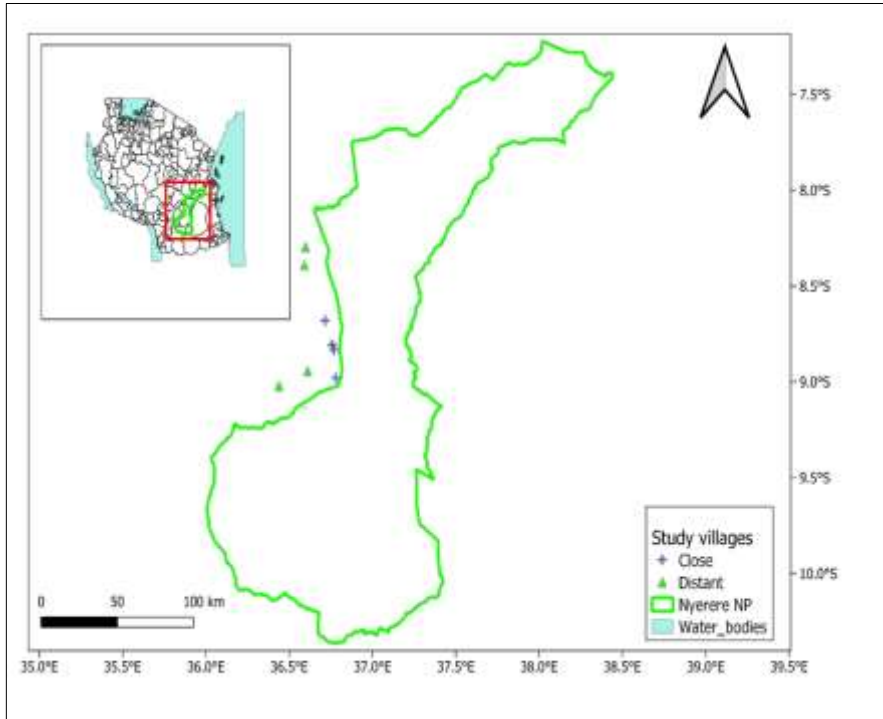


Figure 3.1: Map showing location of Nyerere National Park and the adjacent villages where this study was conducted.

3.2.2 Sampling design

We employed purposive sampling to select four villages less than fifteen kilometres (close villages) and the other four villages located greater than fifteen kilometres (far villages) from the boundaries of WNNP. Preliminary information received from anti-poaching officers was also used to choose the villages. As a result, in addition to selecting villages based on their closeness to protected areas, we also considered that the selected villages experience illicit bushmeat hunting and trade activities. We selected households randomly from the village's register records using online number generator (Georgiev, 2020).

3.2.3 Data collection

We collected data using semi-structured questionnaires administered to household respondents and interview guide to key informants from January to March 2020. For both tools, household surveys and semi-structured interviews were used respectively. We pilot tested the research instrument for household in two villages out of the main study villages to reveal any weaknesses and improve the questions accordingly. Under the assistant of two field assistant and local guide from each village, we interviewed 261 household respondents (≥ 18 years) of which about 80% were males. Proportionally, 52% of household respondents interviewed were located within fifteen kilometers from the park boundaries and 48% were located fifteen kilometers far away from the park boundary. All interviewed respondents participated freely as they were assured that none of their information will be disclosed. Also, we translated our questionnaire into widely spoken national language (Swahili). To encourages fully participation of the respondents and give them room to speak out their opinion openly, both open and close ended questions were employed. We divided the questionnaire into two major parts.

The first part of the questionnaire collected basic information concerning the socio-demographic properties of the respondents (gender, age, ethnicity, period of residence, level of education and occupation). The second part of the questionnaire explored information on the practices and behavioral risks exposing respondents to possible zoonosis. We asked respondents to state if they experienced any contacts with wild animals and /or their products (bushmeat, skin, blood, carcass etc.) Also, respondents were asked to state if they had consumed bushmeat. For those who reported to consume bushmeat, we asked them about their protein consumption preferences (bushmeat vs domestic meat) and the likely reason for their choice. We then explored the knowledge of the respondents regarding the chance of getting zoonosis through bushmeat consumption and/ or handling of wildlife products.

We also interviewed eight key informants, including District Livestock Officers (02), District Game Officer (01), and conservation personnel (05) from the protected area management in order to gain insight into the current and historical background of zoonotic as well as conservation and health-related issues. Additionally, we obtained secondary data on the zoonotic cases from the district medical records.

3.2.4 Data analysis

We compiled data in Microsoft Excel and conducted a statistical analysis using R software (R Core Team, 2020). We used the χ^2 test to assess the differences in the number of respondents regarding the; knowledge concerning the likelihood of getting zoonosis through handling of wildlife products and bushmeat consumption, the extent to which local people contact wildlife products and/ or consume bushmeat, and bushmeat preferences to domestic meat. Also, we employed a Generalized Linear Model (GLM) with binomial error distribution to assess how distance from the park boundary affected response probabilities of local communities who responded either “Yes” or “No” based on bushmeat consumption, preference, and handling of wildlife products. Moreover, we performed GLM binomial model to determine important demographic factors influencing respondents’ responses towards handling of wildlife products and/or bushmeat consumption. The explanatory variables included in the model were age, residence period, education level, gender, household size, and park proximity (close, far). All GLM binomial models were performed by selecting the family of binomial model distribution. In the GLM, the binomial model that involved multiple demographic factors, step Akaike Information Criterion (AIC) function from the MASS package was used to determine adequate or final model that was plausible (<4 delta AIC) and had the lowest AIC score.

3.3 Results

3.3.1 Knowledge of local communities on zoonotic diseases

About 57 percent of local communities were not aware of the possibility of getting zoonotic diseases from consumption of bushmeat and/ or handling of wildlife products. However, such difference was not statistically significant among respondents ($\chi^2 = 2.0164$, $df = 1$, $p = 0.1556$). When we assessed differences in terms of knowledge of zoonosis based on the proximity to the park boundary, there was no significant difference between local communities living closer (<15km) and those living far (>15km) from the park boundary (GLM, Estimate = $0.1122 \pm 0.2504SE$, $Z = 0.448$, $p = 0.654$). Additionally, according to District Livestock Officer, rabies, brucellosis and anthrax are among zoonotic diseases often recorded in the villages. The occurrence of zoonosis particularly anthrax was also supported by conservation officials of the study area. Furthermore, key informants reported that most of the conservation programs adjacent to western Nyerere National Park were mainly conducted to raise awareness on issues pertaining to the benefits accrued from conservation, and wildlife laws.

3.3.2 Extent of local communities contacting wildlife products

There was a significant high proportion (83%, $\chi^2 = 43.56$, $df = 1$, $p < 0.0001$) of respondents who had contacted wildlife products (Fig. 3.2A) or had consumed bushmeat (79%, $\chi^2 = 33.64$, $df = 1$, $p < 0.0001$, Fig. 3.2B). When assessed in relation to park proximity, the study found a marginal significant decrease of contact probability with an increase of distance from park boundary (GLM, Estimate = $-0.7532 \pm 0.3856SE$, $Z = -1.953$, $p = 0.051$, Fig. 3.3A), while no significant difference was revealed in relation to bushmeat consumption (GLM, Estimate = $-0.4072 \pm 0.3074SE$, $Z = -1.325$, $p = 0.185$, Fig. 3.3B).

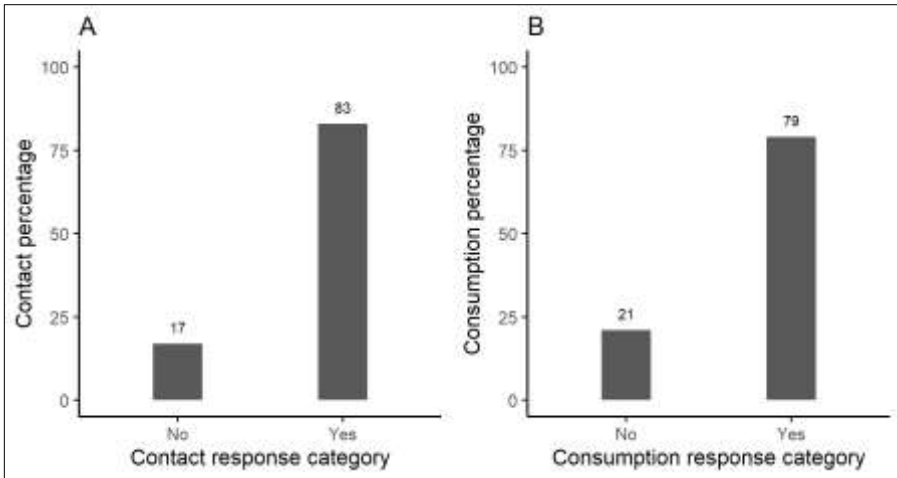


Figure 3.2: Proportion of local community that had contacted wildlife products (A) or consumed bushmeat (B).

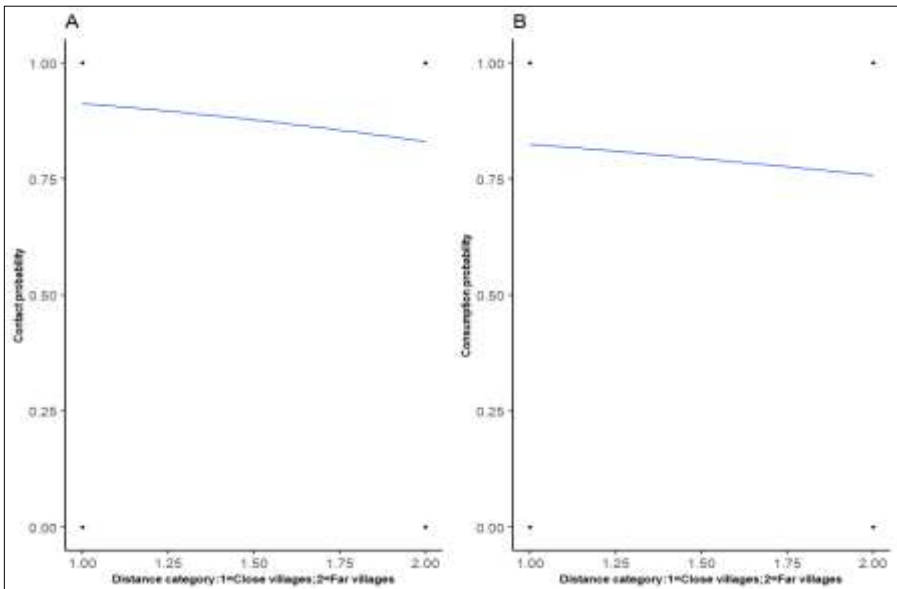


Figure 3.3: Relationships between contact probability of local community to contact wildlife products (A) or consume bushmeat (B) with the distance from the park boundary.

3.3.3 Local communities' meat preference

There was a significant difference of respondents' frequency proportions towards protein preference ($\chi^2 = 58.95$, $df = 2$, $p < 0.0001$). About 70 percent ($n = 183$) of local communities preferred bushmeat to domestic meat (Fig. 3.4). Respondents who showed preference to bushmeat argued that the meat; has good taste, contains high nutrients, has a medicinal effect, not induced with any chemical, soft and free of diseases. When bushmeat preference was assessed in relation to park proximity, the difference was not statistically significant between the villages located closer to, and those distant from the park boundary (GLM, Estimate = $-0.0448 \pm 0.3438SE$, $Z = -0.130$, $p = 0.8963$), suggesting that bushmeat consumption is wide spread irrespective of distance gradient to source.

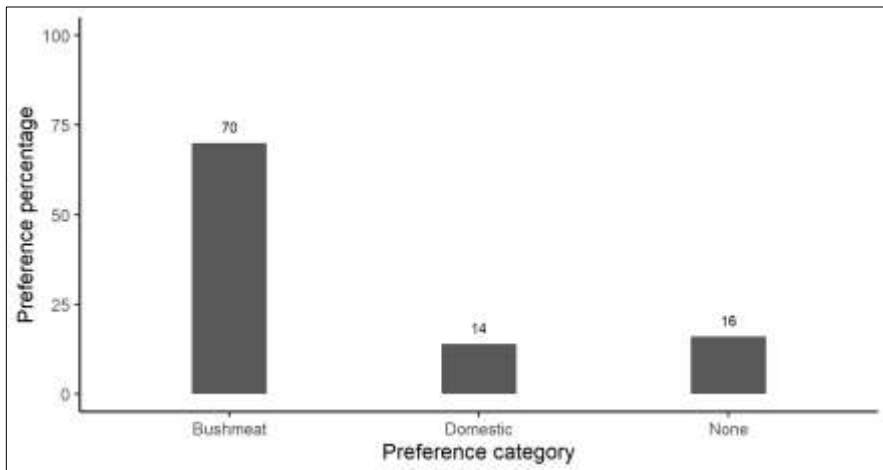


Figure 3.4: Proportion of frequencies of local community showing the preference to bushmeat, domestic meat or none.

3.3.4 Demographic and spatial factors influencing contact or bushmeat consumption of wildlife products

The final model for the factors influencing local communities' response variation over the contacts with wildlife products revealed that residence period was only a significant factor that influenced respondents' behavior. Local residents were more likely to have contacted wildlife products than immigrants (GLM, Estimate = 1.868 \pm 0.566SE, Z = 3.299, p = 0.0009, Fig. 3.5). Furthermore, the final model for factors determining the rate of bushmeat consumption among local people revealed that age and residence were the most significant factors. It appeared that the likelihood for respondents to consume bushmeat increased with an increase of age (GLM, Estimate = 0.0585 \pm 0.0208SE, Z = 2.815, p = 0.0049, Fig. 3.6A) and that residents were more likely to consume bushmeat than immigrants (GLM, Estimate = 1.5583 \pm 0.5929SE, Z = 2.628, p = 0.0086, Fig. 3.6B).

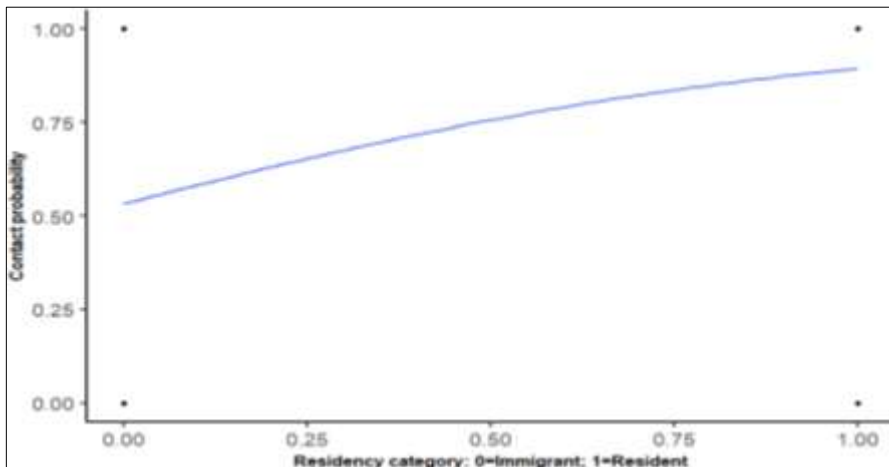


Figure 3.5: Relationships between local community probability of contacting wildlife products with the respondent residence time.

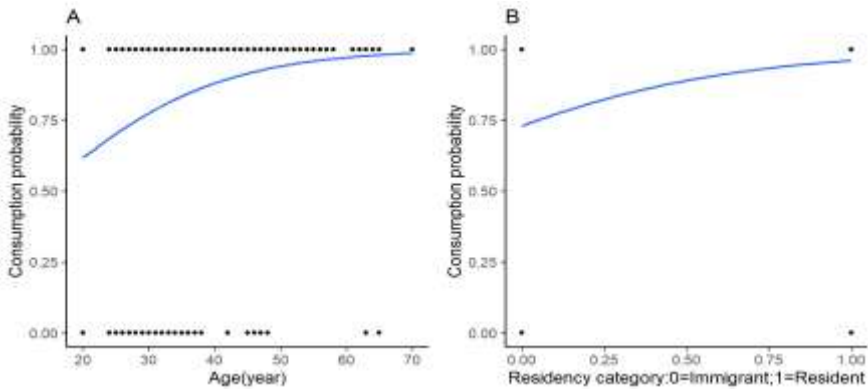


Figure 3.6: Relationships between local community probability of bushmeat consumption with the respondent age (A) and residence (B).

3.4 Discussion

Results of the current study demonstrated that a slightly higher proportion (57%) of local people were unaware of potential health risks associated with bushmeat consumption and handling of wildlife products, and that the likelihood of people contacting wildlife products is higher for communities living close to park boundaries. This means a high chance of zoonotic spill-over in the villages if an outbreak occurs because of the risky behavioural practices among respondents. Moreover, it appeared that local residents >40 years of age were at higher risk of getting zoonotic disease through bushmeat consumption.

3.4.1 Knowledge on possibilities of wildlife zoonotic infections

Our findings revealed a mixed proportion of local people regarding zoonotic diseases originating from wildlife, whereby nearly half of them were aware of the chance of getting zoonotic diseases through bushmeat consumption and handling of wildlife products, and the other group unaware of any such concerns. This is in contrary to other research findings in which the majority of the local people were ignorant of the potential risks of zoonotic disease (Ozioko *et al.*, 2014; Namusisi *et al.*, 2021). Despite our findings indicating the

existence of knowledge among local community members about potential health risks associated with bushmeat, further measures should be taken to increase awareness. This is signified by district records in the study area, which document livestock and human cases of diseases associated with wildlife. Awareness raising about such diseases should be an ongoing process as the study area is also recognized to be a stretch of re-emerging zoonosis (Wensman *et al.*, 2015).

3.4.2 Extent of contacting or consuming wildlife products

Our research found that a large proportion of local communities (approximately 80%) consumed bushmeat and have contact with wild animal products. According to research studies, various actions that bring humans into contact with wildlife products may trigger zoonotic transmission (Subramanian, 2013; Can *et al.*, 2019; Mhlanga, 2020). The fact that significant number of local people experience contact with wildlife products such as blood, carcasses, skin, tails, and feces imply that they are at risk of contracting zoonotic diseases. On the other hand, we found that local communities residing near park boundaries were more likely to come into contact with wildlife products and consequently get zoonotic infections than those located far away. These findings support Mgawe *et al.* (2012) and Manyama *et al.* (2019), who found similar behaviour among local communities living close to parts of the Rungwa-Katavi ecosystem and the western part of Serengeti National Park, respectively. Interestingly, our studies also revealed that the level to which locals consume bushmeat is consistent independent of distance from park boundaries. This implies that despite higher contact probability for communities living near the park perimeter, bushmeat consumption covers a large area. This signals that remote groups could as well be infected through bushmeat consumption in the event of an outbreak. Overall, our findings regarding bushmeat consumption and the handling of wildlife products are indicative of local community engagement in risky health practices that may trigger zoonotic transmission. In this

particular concern, it is essential for conservation and public health programs to increase awareness in the community by emphasizing how interaction with wild animal products through handling and consumption of unlawful bushmeat may be detrimental to human health.

3.4.3 Meat preference by local communities

Our findings showed that local communities preferred bushmeat to domestic meat. Other research studies (van Vliet and Mbaza, 2011; Lindsey *et al.*, 2012; Nguyen *et al.*, 2021), demonstrated comparable preference behaviour among groups. It has been well documented that consumption of bushmeat increases the chances of pathogenic transmission of zoonotic diseases (Clifford *et al.*, 2013; van Vliet *et al.*, 2017; Kriegel *et al.*, 2019; Pruvot *et al.*, 2019; Schilling *et al.*, 2020). Apparently, most locals felt that because wild animals live in their natural environment and were not vaccinated, they were disease-free and hence safe to consume. Such an incorrect notion about the safety of bushmeat assumes that locals will continue to consume it despite being aware of its possible health concerns. This misunderstanding may enhance bushmeat preference behavior and hamper efforts to reduce unlawful bushmeat eating. Therefore, along with other approaches such as diversifying sources for acquiring proteins and income (Rentsch and Damon, 2013; Rogan, 2015; Dindé *et al.*, 2017), we encourage conservation effort to focus on transforming people's behaviour towards bushmeat preference and consumption. This might be efficiently accomplished by collaborating with public health institutions during conservation awareness initiatives.

3.4.4 Demographic and spatial factors influencing respondents' behaviour

Our study demonstrated that local people who have lived in the village for more than ten years had a higher a higher contact probability with wildlife products than immigrants. Similarly, we found that both residents and adults aged 40 years and above were more

likely to have consumed bushmeat. The higher contact probability and bushmeat consumption among residents and adults could indicate that they are the ones who regularly engage in bushmeat-related activities. Our findings, however, suggest that public health efforts aimed at raising zoonotic disease knowledge should place a greater emphasis on residents and adults, since they may have a greater influence on bushmeat intake. Targeting a specific group has been shown to be one of the most effective ways for combating zoonotic concerns (Gilbert *et al.*, 2014; Islam and Ahmed, 2019; Namusisi *et al.*, 2021).

3.5 Conclusions and Recommendations

3.5.1 Conclusion

The present study revealed that local people adjacent to Western Nyerere National Park are more likely to be infected with zoonotic pathogens through bushmeat consumption and/or handling of wildlife products. Nevertheless, the chance seems to be higher among adults >40 years of age. Designing public health programs to ensure that residents, mostly adults are well informed on the likely risks of zoonosis could be among effective means to increase knowledge and awareness and subsequently reduce the likely risks in the future.

3.5.2 Recommendations

Firstly, improving conservation education programs through introducing issues related to zoonotic disease. This might be accomplished by undertakings awareness campaigns that focus on alerting people regarding the potential health risks related to the handling of wildlife and consumption of bushmeat originating from illegal or uncertain sources. However, we further recommend that the conservation authorities of the area also involve personnel from public health institutions during their awareness campaigns to ensure that the issue of zoonotic disease is addressed accordingly.

Secondly, given the current global concern about the potential health risks posed by wildlife, Tanzania's education curricula should be revised and improved such that zoonotic diseases are covered beginning in primary school. This will help to raise people's understanding and awareness, regardless of how distant their villages are from the park's boundaries.

Thirdly, enhancing public health knowledge with the goal of transforming people's habits and beliefs regarding bushmeat consumption and preference behaviour should be made a pertinent agenda. It has been noted from our findings and other literature that people prefer bushmeat because of the belief that "wild animals are safer than domestic animals since they live in an uncontaminated environment." This notion may be misleading and encourage people to consume bushmeat despite the known possible human health consequences. Thus, alerting people to the potential risks associated with wild meat might be an effective means to reduce consumption and preference.

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Authors Contributions

YRF designed, conducted the study and developed the manuscript; SNH guided development of research proposal, execution of field work and reviewed the manuscript; RMJK and CPM reviewed the manuscript; and MHK helped with statistical data analysis.

Conflicts of Interests

The authors declare no conflict of interest

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CHAPTER FOUR

4.0 Do Communities Understand the Impacts of Unlawful Bushmeat Hunting and Trade? Insights from Villagers Bordering Western Nyerere National Park Tanzania

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Abstract

Assessing local people's understanding of the consequences of unsustainable bushmeat-related activities on conservation is an important step toward developing effective solutions to decrease unlawful hunting activities. The current study investigated the knowledge regarding the ecological and socioeconomic impacts of illegal bushmeat activities among villagers adjacent to western Nyerere National Park Tanzania. The two terminologies i.e., “hunting” and “trade” were collectively used herein as “bushmeat trade”. We collected data from 261 households and 24 key

informants using a semi-structured questionnaire and an interview guide, respectively. Results show that 84% of local residents know that bushmeat trade directly threatens wildlife by reducing the population of hunted species. Nearly half of the respondents also appreciate the benefits of wildlife conservation. Regarding the trend of bushmeat trade in the study area, the majority (80%) of the respondents stated that the activity is decreasing. Moreover, the study revealed that the knowledge variation regarding the impacts of bushmeat trade is significantly influenced by education level, age and proximity to the park boundaries. Interventions aimed at addressing the illegal bushmeat trade should consider demographic factors and ensure that conservation programmes are extended to both nearby and distant villages from the park boundaries for enhanced and impactful results.

Keywords: wildlife conservation, illegal hunting, local communities, impacts, knowledge variation

4.1 Introduction

There has been widespread concern about the impacts of illegal bushmeat hunting on biodiversity conservation (Rija *et al.*, 2020; Sackey *et al.*, 2022). The consequences of unlawful hunting directly and indirectly affect the socioeconomic livelihoods of people (Price, 2017; Rogan *et al.*, 2018). Yet, most local people in developing countries with vast wildlife resources engage in illegal bushmeat hunting (Twinamatsiko *et al.*, 2014; Peros *et al.*, 2021; Nana *et al.*, 2022). Numerous factors have been documented to contribute to the prevalence of illegal bushmeat activities. These factors encompass the absence of alternative livelihoods, the search for protein substitutes, the adherence to cultural practises and traditions, and individual preference behaviour (van Vliet and Mbazza, 2011; Nyaki *et al.*, 2014; Chausson *et al.*, 2019; Morrison-Lanjouw *et al.*, 2021).

In various regions of Africa, the illegal killing of wildlife for the purpose of bushmeat trade and/or personal consumption is

predominant among communities residing near protected areas designated for wildlife conservation (Luiselli *et al.*, 2019; Malik *et al.*, 2019; Bannor *et al.*, 2021; Torres *et al.*, 2021). This unsustainable exploitation of wildlife by local communities has been identified as a contributing factor to the global decline in wildlife populations (Craigie *et al.*, 2010; Ripple *et al.*, 2016; Rija *et al.*, 2020). The ecological ramifications of the bushmeat trade signal the importance of safeguarding the remaining wilderness areas, including those located within the protected lands in Africa (Lindsey *et al.*, 2015; Wilkie *et al.*, 2016; Sackey *et al.*, 2022).

Similar to many other developing nations, Tanzania has set aside a substantial portion of its territory for wildlife conservation (URT, 2014; Kideghesho, 2016). Unfortunately, the majority of the country's protected areas have been identified as being threatened by illegal bushmeat hunting for consumption and income generation (Ceppi and Nielsen, 2014; Fischer *et al.*, 2014; Rogan, 2017; Manyama *et al.*, 2019). Given the consequences associated with illegal wildlife activities, such as loss of revenue, loss of employment opportunities, increased conservation expenditures through anti-poaching patrols, and other related reinforcements (Lindsey *et al.*, 2011; Rogan, 2015; Price, 2017), it is evident that such illegal activity negatively affects the socioeconomic well-being of people.

The Tanzania Wildlife Policy of 2007 (URT, 2007) highlighted the importance of undertaking necessary measures to safeguard wildlife and its habitats as a means to counteract the rising trend of illegal wildlife activities. To achieve this goal, a series of conservation initiatives have been implemented, focusing on providing conservation education and supporting community development projects (Sungusia, 2010; Mwakaje *et al.*, 2013; URT, 2015; Mawi and Mashene, 2019). However, despite the implementation of these initiatives to enhance conservation knowledge, research studies have revealed the persistence of unlawful hunting and bushmeat operations in areas where these approaches have been employed

(Kiffner *et al.*, 2015; Rogan, 2017). This underscores the need for further research to obtain a comprehensive understanding of people's knowledge regarding various aspects of conservation, including the ecological and socioeconomic impacts associated with unsustainable bushmeat hunting and trade. So far, there is a substantial body of literature that extensively covers the detrimental effects of illegal hunting activities within and beyond Tanzania's protected areas (e.g., Bitanyi *et al.*, 2012; Gandiwa *et al.*, 2014; Ariffin *et al.*, 2018; Angwenyi *et al.*, 2021; Foya *et al.*, 2023). Nevertheless, indigenous knowledge of the ecological and socioeconomic implications of bushmeat hunting and trafficking in communities surrounding protected areas is yet to be investigated. By tapping into the insights and perspectives of local communities, it becomes possible to pinpoint the gaps in current conservation efforts and develop targeted strategies that align with the specific needs and concerns of the communities involved. This approach fosters a more inclusive and holistic approach to conservation, enhancing the overall effectiveness of conservation initiatives (Wali *et al.*, 2017; Ntuli *et al.*, 2019).

Therefore, the current study aimed to address the existing knowledge gap concerning the ecological and socioeconomic impacts of illegal bushmeat hunting and trade (hereafter referred to as "bushmeat trade") on both conservation efforts and local communities. Specifically, the study aimed to focus on (i) the knowledge of local people on the negative impacts of bushmeat trade on wildlife populations and trend of bushmeat trade over the past five years (2014 to 2019); (ii) the knowledge of local people regarding the socioeconomic importance of wildlife conservation; and (iii) the demographic and distance factors (nearby and distant) that might influence conservation knowledge among respondents. In this study, local people's knowledge was gathered through the administration of several sets of subject-related questions to respondents. This approach is consistent with the methodologies and insights provided by both Hunt (2003) and Matoková (2016).

4.2 Methods

4.2.1 Study area

The Nyerere National Park, covering an area of 30,893 km², is the largest national park in Africa. It was formed after the former Selous Game Reserve (SGR) was divided into two parts; one section retained the SGR name, while the larger portion was renamed as the “Nyerere National Park”. This park is located between 7.75° and 10.5° South and 36.0° and 38.7° East (Fig. 4.1). The area has annual rainfall ranging between 750 and 1300 millimetres (Balus and Hhan, 2009). The park is home to several wild animals, including threatened species such as the endangered (EN) African elephant (*Loxodonta africana*), near threatened (NT) African Cape buffalo (*Syncerus caffer*), the vulnerable (VU) Hippopotamus (*Hippopotamus amphibius*), the critically endangered (CR) African wild dog (*Lycaon pictus*), several other predators, and a variety of antelopes (UNEP-WCMC, 2011; TAWIRI, 2019). Extensive miombo forest characterized by *Brachystegia sp*, *Julbernardia sp*, *Isoberlinia sp*, *Azelia quanzensis*, and *Pterocarpus angolensis* dominates the region (Balus and Hhan, 2009).

The current study was conducted in eight out of 26 villages around the western part of the park, Ilonga (>7,500 km²), referred to henceforth as western Nyerere National Park (WNNP). The villages are in Ulanga District, southwest of Morogoro town. The WNNP is also close to Iluma Wildlife Management Areas (IWMA) and Kilombero Game Reserve, a protected area known to harbour a sizeable population of the Puku antelope, *Kobus vardonii* (Haule *et al.*, 2002). In general, the research area receives a bimodal distribution of rainfall, with brief rains from November to January and long rains from March to May. Although the area is inhabited by several tribes, including Pogoro, Ndamba, Ngindo, Ndwewe, and Sukuma, Pogoro is the largest ethnic group. In the selected villages, households engage in diverse socioeconomic endeavors such as crop farming, poultry husbandry as well as operating small-scale businesses such as shops and local markets where they sell locally-

produced products and items for household needs. Beside aforementioned activities, it was disclosed by key informants that illegal bushmeat operations are prevalent in these areas, with Hippopotamus *Hippopotamus amphibius*, Buffalo *Syncerus caffer* and Hartebeest *Alcelaphus buselaphus lichtensteinii*, being among the most hunted species for trade and household consumption.

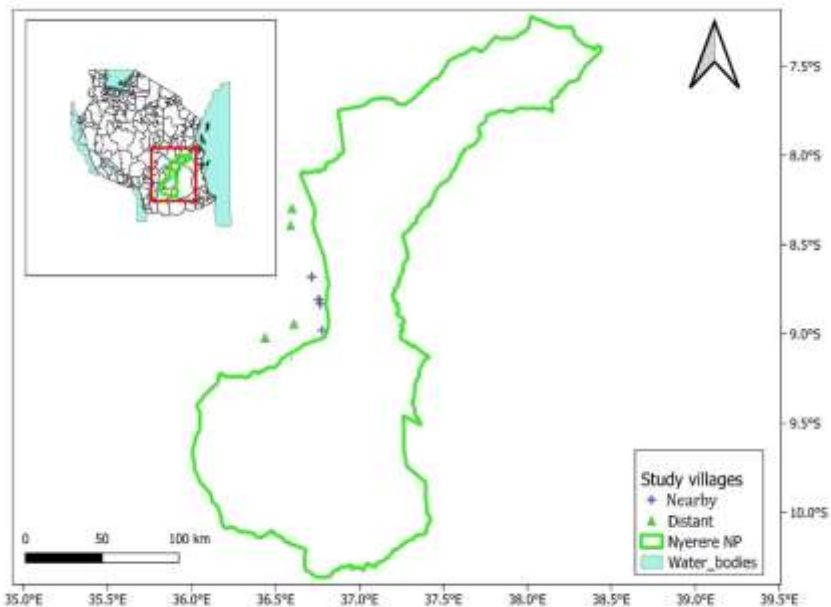


Figure 4.1: A map showing Nyerere National Park and the villages where this study was conducted. The plus signs indicate villages located within 15km of the WNNP boundary, herein classified as “nearby villages” while the triangle signs indicate villages beyond 15km, herein classified as “distant villages”. Both distant and nearby villages were also selected based on their involvement in illegal bushmeat hunting and trading activities. On the top left corner is the map of Tanzania showing the location of Nyerere National Park (in rectangle)

4.2.2 Sampling of villages and respondents

The study villages were purposefully selected according to distance from the boundaries of the park (Wilfred *et al.*, 2019). Following a preliminary conversation with conservation managers and other key informants in the area, eight villages where bushmeat hunting for household consumption and trade were identified and selected. The geographic coordinates for each village were recorded using a hand-held GPS device, and the data was subsequently imported into a computer and analyzed using ArcGIS software to determine the relative positions of villages and distances on a map. From a list provided by key informants, four villages directly bordering the WNNP boundary were chosen. These villages were located within 15 kilometres of the WNNP boundary, hence being classified as “nearby villages”. Conversely, another set of four villages, identified by key informants as not directly bordering the WNNP boundary, were chosen. These villages were located more than 15 kilometres away from the WNNP boundary, hence being classified as “distant villages”. However, because of the sensitivity of studies dealing with the unlawful use of wildlife, and to adhere to the ethical research requirements for conducting such studies, the identities of the communities were withheld (UNEP-WCMC, 2020).

To select the households, the names were randomly picked from the village record book in each village using an online random number generator (Georgiev, 2020). We also deliberately selected key informants from various levels, including the district, village, and conservation area authority, based on their roles. At the district level, we interviewed the District Game Officer, who acts as a liaison between the community and the government, and overseeing matters such as benefit sharing from natural resources. In each village, we interviewed the village executive officer and village chairperson, who, along with other officials, participate in supervising the community development projects. Additionally, conservation officers were interviewed to gather insights related to wildlife conservation in the area, including their responsibilities in ensuring

that local communities benefit from wildlife conservation.

4.2.3 Data collection

The current study employed a cross-sectional approach, which permits the gathering of data within a limited time frame. The data was collected between January and March 2020. Prior to conducting household surveys in the sample villages, we pilot-tested our research instruments in two villages outside the primary study villages and then modified the questions accordingly (Chaudhary and Israel, 2014; Ikart, 2019). To ensure the consistency of our results, the two villages selected for pretesting had comparable socio-demographic features. To meet the recommended number of responses for pretesting, a total of 32 individuals were polled (Perneger *et al.*, 2015).

During our main household survey, at least 30 households from each village were interviewed, resulting in a total of 261 respondents. These respondents were selected from both nearby villages (137 respondents) and distant villages (124 respondents). We specifically selected the household head, a senior member, or any adult over the age of 18 who was present at home for the interviews. Most respondents (79%, $n = 205$) were males, while only 21% ($n = 56$) were females. The number of males was proportionally higher than females due to the nature of the study design, which relied on household heads, the majority of whom were men. The majority of respondents were between the ages of 29 and 39 (40%, $n = 105$), followed by the 40–50 age group (26%, $n = 68$), the 18–28 age group (23%, $n = 59$), and a smaller proportion were above the age of 50. Most of the respondents (77%, $n = 202$) had completed primary education, while 13% ($n = 35$) had secondary education, and 9% ($n = 24$) had informal education.

Due to the illegality of bushmeat in the study area, the questionnaire was developed to introduce the subject gradually. The first section of the questionnaire inquired about the respondents' demographic characteristics (gender, age, ethnicity, period of residency, level of

education, and occupation). The second section of the questionnaire gathered data on the ecological and socioeconomic consequences of wildlife conservation. Therefore, we inquired about the negative consequences of illegal bushmeat hunting and trading on wildlife populations as well as the general trend of bushmeat trade in the study area during the past five years. In addition, we investigated respondent's knowledge about the benefits of wildlife conservation in the area and whether demographic factors and distance from the park boundary to villages accounted for poachers' involvement in the bushmeat trade.

Furthermore, we conducted semi-structured interviews with 24 key informants, including 16 village officers (one village executive officer and village chairperson, respectively, from eight villages), the District Game Officer, and seven conservation officers. This allowed us to gather secondary data, including records of community development initiatives and tourism-based activities. The interviews were done with the participants' informed consent, and anonymity and confidentiality were assured.

4.2.4 Data analysis

Data were analyzed using the R statistical software (R Core Team, 2020). For categorical data, the Chi-square test was used to assess differences in respondent frequencies in the aspects related to local people's knowledge of the negative impacts of bushmeat trade; the perceived trend of wildlife populations and bushmeat trade activities in the study area; and the socioeconomic importance of wildlife conservation to local communities. For binary variables, a Generalized Linear Model (GLM) with binomial error distribution was used to determine how distance from the park boundary affected the response probabilities of respondents who responded either yes or no based on the negative effects of bushmeat trade on wildlife population and trend. Finally, a GLM binomial model was used to assess the demographic characteristics that influenced variance among respondents on the effects of bushmeat trade on wildlife. All GLM binomial models were

performed by selecting the family of binomial model distribution. The GLM binomial model that involved multiple demographic factors, and final model with parsimonious significant factors were determined by using step AIC function from the MASS package.

4.3 Results

4.3.1 Negative impacts of bushmeat trade

When asked about the impact of bushmeat trade on wildlife populations irrespective of proximity to the park, a significantly higher proportion (84%) of respondents knew that bushmeat trade may diminish local wildlife populations while 16% had no such understanding ($\chi^2 = 23.871$, $df = 2$, $p < 0.0001$). When asked to provide their views on the trend of bushmeat trade over the past five years, approximately 80% of respondents declared a significant decrease in illegal bushmeat trade compared to 20% who reported not being aware of the status whereas none reported an increase in illegal bushmeat trade ($\chi^2 = 31.36$, $df = 1$, $p < 0.0001$, Fig. 4.2). The decrease in bushmeat trade was also supported by interviewed officials from TAWA, who formerly managed the area before it was gazetted as a national park in November 2019 (a year before the study period). When assessing variation in local knowledge about the trends of bushmeat trade with park proximity, we found a marginal difference between those living in nearby villages and those in distant ones (GLM, Estimate = $-0.6470 \pm 0.3477SE$, $Z = -1.861$, $p = 0.0628$, Fig. 4.3). The knowledge probability of the trend of bushmeat trade is high in villages near the park boundary and decreases further away from the park boundary.

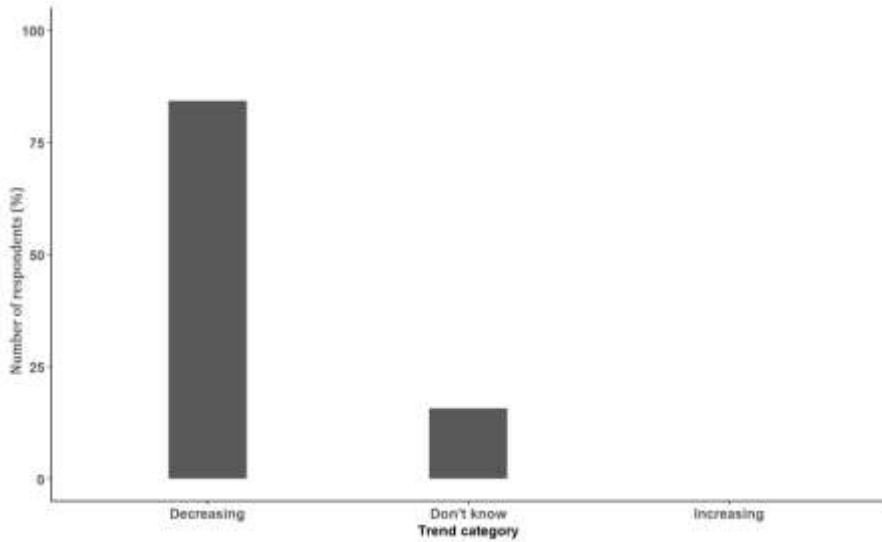


Figure 4.2: Knowledge of local communities on the trend of illegal bushmeat trade irrespective of village distance from the park boundary. Category “Decreasing” (N=220) represents respondents who said illegal bushmeat trade was decreasing while “Don’t know” (N=41) represents those who did not know the status. None of the respondent said illegal bushmeat trade is increasing.

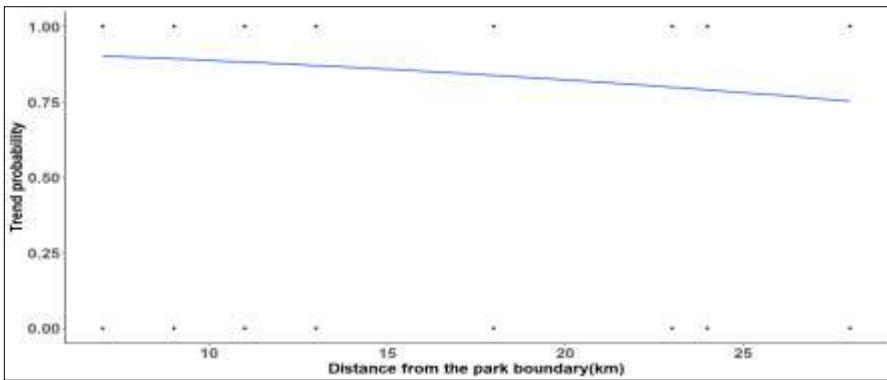


Figure 4.3: Knowledge probability level on the trend of bushmeat trade in the past five years between villages living near the park boundary and those living in distant ones. The representation indicates the knowledge variation of respondents regarding the trend of bushmeat trade with respect to distances. The blue line indicates the regression line generated from the Generalised Linear Model (GLM).

4.3.2 Social-Economic Importance of Wildlife Conservation to Local Communities

The study assessed the differences between the positives (benefits) and negatives (costs) of wildlife conservation to local communities living adjacent to western Nyerere National Park and found that the proportion of respondents who acknowledged the advantages of wildlife conservation (48.7%) was quite close to the proportion of respondents who believed wildlife conservation provided no value (44%). Furthermore, the 44% (n = 54) out of 124 respondents from distant villages and 53% (n = 73) out of 137 respondents from nearby villages agreed that conservation is beneficial. The benefits mentioned by respondents who were positive about wildlife conservation included the; increased government funding and support for community development initiatives, the development and expansion of businesses in the villages, temporary employment, and

community security. However, when we assessed the knowledge variation regarding the benefits of wildlife conservation with respect to proximity to the park, the study found a non-significant decrease in benefit probability for local communities living nearer to the park boundary compared to those who live in distant villages (GLM, Estimate = -0.3885 ± 0.2590 , $Z = -1.500$, $p = 0.134$).

When we interviewed village officers from nearby and distant villages, they acknowledged that their communities have been supported with funding derived from wildlife resources. While the level of support varied among villages, the key informants discussed some of the benefits associated with wildlife conservation. These benefits were derived from tourism companies and government funding, which stemmed from the sharing of benefits obtained from wildlife resources. For nearby villages, funds were provided for the construction of four classrooms, two toilet buildings, and the renovation of a nursery school, whereas for distant villages, funds were provided for the maintenance of a water borehole, the construction of two classrooms, 164 roofing sheets for three classrooms, 40 class chairs, and 40 tables for secondary schools. The District Game Officer reported that the district council has been receiving from the government part of the revenue accrued from the wildlife resources to support communities surrounding the WNNP, including the surveyed villages. The information reported by respondents was further reinforced by the conservation officers, who stated that apart from government revenue distribution to villages living adjacent to the WNNP, local tourism enterprises were obliged to contribute to the development of community projects each year.

4.3.3 Demographic and distance factors influencing respondents' knowledge

The observed variation among respondents about the impacts of bushmeat trade was significantly associated with the level of education and marginally associated with proximity to the park boundary and age of the respondents. The awareness probability

increased considerably with education level (GLM, Estimate = $2.9737 \pm 0.7603\text{SE}$, $Z = 3.911$, $p = 0.0001$), in which respondents with at least primary education were more aware about the impacts of bushmeat trade than those with informal education levels. (Fig. 4.4A). Villages nearer to the park are more aware about the impacts of bushmeat trade and this pattern decreases marginally as the distance from the park boundary increases (GLM, Estimate = $0.033 \pm 0.019\text{SE}$, $Z = -1.661$, $P = 0.097$, Fig. 4.4B). Furthermore, it was noted that individuals over the age of 40 demonstrated a higher level of awareness regarding the consequences of the bushmeat trade compared to the younger population (GLM, Estimate = $0.027 \pm 0.014\text{SE}$, $Z = 1.926$, $P = 0.054$, Fig. 4.4C).

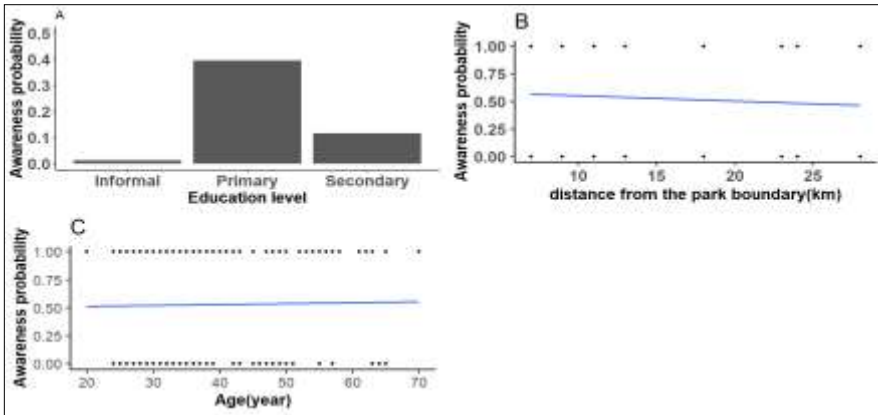


Figure 4.4: Relationships of knowledge of local communities with education levels (A), distance from the park boundary (B) and respondents age (C). Dots on subplot B and C represent binary responses of local communities on which part of them were aware (shown by dots found perpendicular to number 1, and other part of respondents were not aware (shown by dots found perpendicular to number 0). The blue lines represent regression lines generated by Generalised Linear Models (GLM)

4.4 Discussion

According to our findings, local residents in the study area were knowledgeable that the bushmeat trade may lead to the extinction of wild animals, demonstrating that they knew the impact of the illegal bushmeat trade on wildlife populations. Conservation officers have concurred with the observations of respondents, noting a decline in illegal bushmeat hunting and trading since 2014. This trend of diminished illegal bushmeat activities is also reflected in findings from other regions in Tanzania (Andimile and Floros, 2021). According to TAWIRI (2019), the wildlife populations in the ecosystem encompassing the study area are now recovering as a result of a decrease in illegal wildlife activities over the past years. This appears to match what our respondents stated. Thus, our

results suggest that local community knowledge can make a substantial contribution to giving a comprehensive picture of the state of illegal wildlife operations in the protected area. Hence, their knowledge can be further explored to provide strategies for reversing illegal wildlife operations in protected areas.

The respondents had mixed feelings about the benefits of wildlife conservation, with approximately half of them being knowledgeable and the other half claiming to be unaware of the benefits. Our data showed that respondents' disagreement over the advantages of conservation may be attributable to the negative socioeconomic implications of human-wildlife interactions. Respondents contended that wildlife provides no advantage due to crops damage, livestock depredation, loss of life and injuries, and a lack of direct monetary benefit. However, our interviews with key informants including village officers revealed that wildlife conservation has supported various community development projects and provided job opportunities. This indicates that the lack of appreciation for wildlife conservation among certain community members does not necessarily imply their ignorance of the benefits. Instead, they might be hesitant to acknowledge these benefits due to the costs they have incurred through their close interactions with wildlife. These findings align with previous research, indicating that local residents may resist conservation efforts due to the socioeconomic burdens resulting from wild animals in their villages (Synman, 2011; Gemeda *et al.*, 2016; Ochieng *et al.*, 2021). On the other hand, the appreciation of benefits by some of the respondents and key informants from both nearby and distant villages is associated with their awareness that funds used to support community initiatives in their places are primarily dependent on the presence of wildlife (Rogan, 2015; Price, 2017). Such understanding has cultivated a positive attitude towards wildlife conservation, hence co-existence between people and wildlife. In this regard, it is critical for conservation management authorities to also conduct conservation programs that focus on changing people's negative attitude towards wildlife conservation.

This is particularly important because the viability of conservation projects is dependent on the attitudes and understanding of the local population (Mir *et al.*, 2015; Nilsson *et al.*, 2020).

It has been established that the efficiency of conservation projects is dependent on demographic characteristics and other related elements impacting people's behaviour (Mgawe *et al.*, 2012; Gandiwa *et al.*, 2013). Our findings showed that, education level, age and proximity to park boundaries explain variance in the understanding of the consequences of bushmeat trade. We revealed that the chance of comprehending the impacts of bushmeat trade increased with education level. Local inhabitants with at least primary level of education were more aware about the impacts of bushmeat trade than those with informal education levels. This observation is consistent with the idea that formal education provides a platform for individuals to gain insights and knowledge about various environmental and conservation topics (Howe, 2009; de Oliveira *et al.*, 2020; Desi *et al.*, 2021). Thus, efforts aimed at including conservation topics into formal education system can create an early appreciation and respect for wildlife, ensuring that future generations remain dedicated to conservation efforts (Sterling *et al.*, 2017; Kideghesho, 2019). However, our findings further imply that individuals with informal level of educations should be paid special attention when addressing the socioeconomic implications of bushmeat trade. In addition to education, the findings of this study revealed that individuals aged 40 and above exhibited a higher likelihood of understanding the consequences of the bushmeat trade compared to younger populations. This could be due to the older generation's prolonged exposure to the natural environment, allowing them to see directly the tangible impacts of illegal hunting practises on ecosystems and community livelihoods (Nuno *et al.*, 2013). Our findings, however, imply that conservation education efforts should also prioritize younger generations, as they appear have limited awareness regarding the impacts of the bushmeat trade.

On the other hand, our study demonstrated that individuals residing near the park boundaries displayed a higher level of awareness regarding the consequences of illegal wildlife operations compared to those living at a greater distance from the park. The observed trend in the given study is in line with previous research that demonstrates communities living near protected areas are more likely to have a higher stake in the benefits derived from these areas (Abukari and Mwalyosi, 2020; Mbise *et al.*, 2021; Kegamba *et al.*, 2023). However, our key informants in the study area further elaborated that people in the study area benefit from wildlife conservation regardless of their proximity to the park boundaries. This broader perspective reinforces the previous argument that the illegal bushmeat trade could negatively impact villages that are distant from the park boundaries as well. In light of this, effective conservation strategies should not only focus on the communities residing near the protected areas. Broad-based awareness campaigns and community interventions that cater to both nearby and distant villages should be formulated and executed to bridge the understanding gap and ensuring a more holistic approach to conservation (Andrade and Rhodes, 2012; Mogomotsi, 2020).

4.5 Conclusions and Recommendation

The current investigation established local people's understanding of the effects of bushmeat trade. Local people in the study area are knowledgeable that illegal hunting for bushmeat and trade is endangering wildlife populations. Moreover, this study has noted that both nearby and distant villages could be negatively impacted by bushmeat trade. Therefore, it is necessary to address conservation issues in both villages located near and distant from the park boundaries, as well as taking demographic factors such as age and education levels into account.

The proportion of respondents who appreciate versus those who did not recognize the advantages of conservation is of special

significance. Local communities that claimed the absence of benefits from wildlife conservation seemed to have a negative attitude towards wildlife and conservation. To counteract this, we urge that protected area managers seek people's thoughts and address them before the commencement of any development project in the village. This will increase the sense of ownership and support conservation activities targeted at minimizing bushmeat trade.

Disclosure of Conflict of Interest

The authors declare no potential conflict of interest

Data Availability Statement

The data underlying this study are available from the authors upon reasonable request and with permission from the management of the TRADE Hub Research Project at Sokoine University of Agriculture and UNEP-WCMC.

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Ethics Approval Statement and Declaration

This study followed the ethical research standards of the Sokoine University of Agriculture and the UNEP-WCMC Code of Practice on Ethical Standards in Research, and it was approved by the Trade,

Development, and Environment Hub (TRADE Hub) Research Ethics Committee. Official permission to conduct research in the study regions was granted from the Morogoro Regional Office, Ulanga District Council, surveyed village Councils, and conservation authorities (TAWA and TANAPA). Prior to an interview, the purpose of the research was explained and informed consent was obtained from all respondents. Participants were assured of anonymity and confidentiality, and their participation was entirely voluntary; they were allowed to answer questions or quit an interview at any time.

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CHAPTER FIVE

5.0 General Discussion Conclusion and Recommendations

5.1 Discussion

The first chapter of our thesis indicated that illegal bushmeat hunting prevails in different communities adjacent to protected area regardless of the fact that various studies indicated the ecological, socio-economic and potential health impacts associated with the activity. Thus, the reliance of bushmeat for consumption and trade have an implication on the level of understanding of people concerning the illegal bushmeat hunting and its associated impacts. Under this particular concern, we assessed the knowledge of local people adjacent to WNNP and generated crucial information that could help in developing and undertaking effective conservation measures to reduce illegal offtake of wildlife resources as well as increasing conservation awareness to local communities.

The second chapter of our study explored the knowledge and experience of poachers in revealing the spatial-temporal pattern of illegal bushmeat hunting activities. The majority of poachers hunted both inside and outside WNNP and targets wild animals in areas with high probability of occurrences such as near water sources and at farm peripherals during farming season. We found that poachers used the same routes in areas that are not easily accessed by rangers or different routes when they suspect that they are being timed for ambush on their way back to the village. The majority of the poachers (66%) transport bushmeat within the village land and the business is operated in the manner that the exchange involves people who knows each other. It also appeared that majority (74%) of the poachers engage in IBHT during the wet season. This has been geared by ineffective anti-poaching patrol, accessibility of wild animals in vast areas and traditional and religious ceremonies. Of the 12 wild animal species that were identified by hunters, we found that large sized mammals ($\geq 50\text{Kg}$) including Hippopotamus, Buffalo

and Hartebeest were more vulnerable to illegal hunting for bushmeat and trade.

The third chapter of our study demonstrated the knowledge of local people in relation to the potential health risks associated with bushmeat consumption and or handling of wildlife products. Although non-significant, we found that more than half (57%) of the respondents did not know of the possibilities of contacting zoonosis through handling of wildlife products and bushmeat consumption. We demonstrated that the majority of local people (83%) had been exposed to the risks of zoonosis through consumption and or handling of wildlife products. Meanwhile our study found that the probability for exposure through contact is higher for community leaving closer to the park boundary than those leaving far away. Also, our study revealed that the respondent's behavior towards contacting wildlife products is influenced by locality and age. Majority of the local people residing the area for more than five years appeared to had contacted wildlife products than immigrants.

The fourth chapter of our study was based on the assessing the understanding of local communities towards the ecological and socio-economic impacts of bushmeat hunting and trade. The majority (84%) of the respondents agreed that illegal hunting impacts wild animal population by decreasing their number. Meanwhile we found that illegal hunting was perceived to significantly decrease in the study area over the five past years as similarly supported by wildlife personnel in the study area. On the other hand, we found a balanced proportion in terms of number of respondents who agreed to benefits from wildlife conservation and those who claimed wildlife to offer no advantage. However, based on the reasons provided by respondents as to why they disagree that conservation offer no benefit, we found that their knowledge is merely associated with negative attitudes to wild animals and lack of direct benefits. We also found that education and distance to protected areas are significant factors for explaining knowledge

variation towards the impacts of illegal hunting. The likelihood for declaring the impacts of IBHT increased as the level of education increased and decreased as the distance from the park boundary increased

5.2 Conclusions

The current study established local populations' knowledge of the impacts of illegal bushmeat hunting operations. In the first chapter, our study concludes that bushmeat hunting in villages adjacent to WNNP occur in a complex spatial network. Furthermore, we demonstrated that unlawful bushmeat gathering is more widespread in the study area during the rainy season than dry season. The three most commonly hunted wild animals for bushmeat are hippos, buffalo, and hartebeest. In the second chapter, we revealed that people living near western Nyerere National Park are more likely to become infected with zoonotic diseases through bushmeat ingestion and/or handling of animal products. Nonetheless, the risk appears to be larger in individuals over the age of 40. In the third chapter, our study showed that villagers in the surveyed area knew that illicit hunting for bushmeat is threatening wildlife. Improving conservation programs and raising awareness among local inhabitants in surrounding and remote villages should be continuing activities to ensure the survival of wildlife species.

5.3 Recommendations

Regarding the findings from the second chapter, we recommend the management authority of the area to; conduct intensive anti-poaching operations areas located both within and outside the park boundaries. This will help to limit the spatial network for illegal hunting practices hence aid in conservation of wildlife. Based on the third chapter, we recommend the use of different approaches to raise awareness about the potential risks associated with handling of wildlife products and or consumption of bushmeat. For example, we encourage the integration of zoonosis in conservation awareness programs, incorporating zoonotic diseases by starting with zoonotic

diseases of particular concern in our education curriculum. This will help to change people behavior towards bushmeat. In light of the findings from the fourth chapter, education and park proximity plays role in determining the knowledge of people towards conservation issues. Thus, there is a need to increase conservation education to raise awareness to people leaving close to and far from park boundaries.

APPENDICES

Appendix 1: Household survey questionnaire



Sokoine University of Agriculture (SUA)



Department of wildlife management

Introduction

Hello, my name is..... from the Sokoine University of Agriculture (SUA). We are currently doing research to better understand the knowledge of local communities about the impacts of hunting activities. I would greatly appreciate it if you could spare 30 – 45 minutes of your time to complete my research questions regarding bushmeat hunting and wildlife conservation. Your participation in this interview is crucial because the findings will assist in creating effective conservation programmes and strengthen collaboration between local communities and conservation authorities. Your information will be confidential and solely used for research purposes. You are free to withdraw at any time during an interview.

Data storage:

1. Your data will be used by the TRADE Hub researchers, Sokoine University of Agriculture, P.O Box 3007, CHUO KIKUU, Morogoro, Tanzania. Email: saeps@sua.ac.tz; Tel: +255(023)2603415; Fax: +255(023)2601390
2. Data will be stored in the secured email with strong password and a copy of data will be sent to Trade password protected SharePoint folder shared between SUA and WCMC.

Please confirm that:

1. You have read and understand the above terms YES/NO
(please mark as appropriate)
2. You would like your input into this process to be anonymous
YES/NO (please mark as appropriate)

Under these circumstances, you agree to participate in the research:

Village _____ Code: _____

Participant _____ Code: _____

Date: _____

Part One: Socio-demographics Background of the Respondents

1. Gender
A. Male B. Female
2. Age _____
3. Marital status
A. Single B. Married
5. How many individuals reside in your household? _____ (Family members, relatives and others)
4. Ethnicity _____
6. Highest level of education completed _____
7. Period of residency in the village _____
8. Occupation _____
9. Other alternative sources of income

Part Two: Knowledge regarding the wildlife conservation, ecological socioeconomic impacts of illegal bushmeat hunting and trade

10. Have you ever seen any wild animals in your village? Yes/No. If yes, please give the name (s) of the species

11. Are there any wildlife-protected areas near your village? Yes/No.
If yes, please give the name of the protected area (s)

12. Does the conservation of wildlife offer any socio-economic benefits to the local community? Yes/No/Don't know. If yes/no, please provide reason (s) _____
13. Have you heard about the illegal bushmeat hunting activities? Yes/No. If yes, how would describe the term?

14. Does illegal hunting and trading of wildlife species have any impacts on wildlife population? Yes/No/Don't know.
15. Does illegal hunting and trading threaten wildlife species to extinction? Yes/No/Don't know.
16. Do you recognise any illegal hunting or bushmeat activity within and around Western Nyerere National Park during your year of residence? Yes/No. If yes, how would you describe the trend of such activity over the past five years? (2014 to 2019)
A. Decreasing B. Increasing C. Stable D. Don't know
17. Is there any way in which local communities can be negatively impacted socio-economically through rampant bushmeat hunting and trading? (Yes/No). If yes, please provide reason (s)

18. In your perspective, does the government incur any financial costs in its efforts to safeguard wildlife from illegal hunting activities? Yes/No. If so, please provide reason (s)

19. How would you advise the conservation authorities and the government on matters related to wildlife conservation?
20. Have you ever come into contact with wild animal or its product? (Yes/No)
(Touching animals, faeces, bush meat, blood, skin, attacked, bitten)

21. Do you know any diseases transmitted from wildlife to humans through eating or being in contact with an animal or any of its products mentioned above? (Yes/ No) If yes, can you mention the disease

22. Do you know about the potential health risks of wildlife to livestock and/or human? (Yes/No)

23. Have you heard of any health risks to human associated with illegal hunting or handling of wild animal or product? (Yes/No). If yes, can you specify

24. Have you ever eaten uncooked bushmeat? (Yes / No). If yes/No, how many times and why?
(Several times, few times, Never)

25. Do you know any other uses of wildlife product other than for consumption? Target: e.g. Medicinal (Yes/No)

26. Have you heard or experienced any symptoms or discomfort after consumption of bushmeat? (Yes/No). If yes, can you explain?

Have you ever heard of or know any person who has ever suffered from a disease that is associated with bushmeat consumption or handling of wildlife (dead or alive) or any of its products mentioned above? (Yes/No).If yes, explain

27. Do you have any question (s)?

Thank you for your time and participation in this study.

Appendix 2: Reformed poachers



Sokoine University of Agriculture (SUA)



Department of wildlife management

Date:

Location: Western part of Nyerere National Park

Hello, my name is Yohani Rovetha Foya and we would like to thank you for your participation in this interview. We are conducting research coordinated by Sokoine University of Agriculture (SUA) and Trade Hub Research project. We are studying peoples understanding on the impacts of bushmeat hunting and trade to wildlife, socio-economic activities and potential health risks in western part of Nyerere National Park so as to come up with the strategies which will benefit people without compromising conservation activities. Your information in this interview is very important in achieving the objectives of this research. I would like to spend about 30 minutes to get your response for my research questions. Your information will be confidential and only used for research purposes. Your name will not appear in any documents for presentation or publication to ensure that your identification is not revealed and you are free to withdraw at any time during an interview.

Data storage:

3. Your data will be used by the TRADE Hub researchers, Sokoine University of Agriculture, P.O Box 3007, CHUO KIKUU, Morogoro, Tanzania. Email: saeps@sua.ac.tz; Tel: +255(023)2603415; Fax: +255(023)2601390

4. Data will be stored in the secured email with strong password and a copy of data will be sent to Trade password protected SharePoint folder shared between SUA and WCM.

Please confirm that:

1. You have read and understand the above terms YES/NO (please delete as appropriate)
2. You agree for your interview to be recorded YES/NO (please delete as appropriate)
3. You would like your input into this process to be anonymous YES/NO (please delete as appropriate)

Under these circumstances, you agree to participate in the research:

Signature:

Name _____ (please print):

Date: _____

PART ONE: SOCIO-DEMOGRAPHIC BACKGROUND OF THE RESPONDENTS

4. Gender: Male () Female ()
5. Age : A. 18 – 28 B. 29 – 39 C. 40 – 50 D. > 50
6. Marital status: A. Single B. Married
7. Ethnicity: A. Pogoro B. Ndamba C. Ngindo D. Sukuma E. Other
8. Education level: A. Primary B. Secondary C. College D. Informal E. Other (Specify)
9. Family size: A. 1 – 4 B. 5 – 8 C. > 8
8. Residency: A. Immigrants B. Indigenous
9. Occupation: Farmer B. Employee B. Businessman C. Other (specify)
10. Source of income
 - A. Crop farming B. Livestock keeping C. Fishing D. Other (Specify)

PART TWO: HUNTING AND BUSHMEAT TRADE ACTIVITIES

11. For how long have you been in illegal bushmeat hunting and or trade?
12. What are the likely reasons for being engaged in illegal hunting activities?
13. Where do you normally hunt and target for wild animal for bushmeat? (Inside WNNP, Outside WNNP, Other (specify). If inside/outside WNNP which areas in specific?
14. Can you describe the routes taken to enter and leave the protected area?
15. Where is bushmeat taken for consumption and trade after hunting?
16. Which methods do you commonly used during illegal hunting?
17. Which species do you frequently target during hunting?
18. How do you transport bushmeat from one place to another?
19. Is there any variation for illegal hunting and bushmeat trade in the area? If yes specify with reasons?
20. Why do you think is illegal hunting and/or trade high in the period you have specified?
21. At what time do you go for illegal hunting and return back to the village?
15. In what conditions do you sell or distribute bushmeat to consumer/customers or other people? (Dry/fresh/raw /Smoked)
16. Do you know the socio-economic characteristics of people who are currently engaging in bushmeat hunting and trade? If yes, can you categorize the group in terms of:
 - Gender (Male/female)
 - Age.....
 - Ethnicity.....
 - Residency/Inhabitant (Indigenous/immigrants)
.....
 - Education (literate/illiterate)
 - Wealth (Rich/poor)
17. Do you have any question(s)?