ASSESSMENT OF TRADE FLOWS OF WILDLIFE PRODUCTS:

THE CASE OF RUAHA LANDSCAPE, TANZANIA

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EXTENDED ABSTRACT

Wildlife species are utilized and traded in a wide range of items, including food, clothing, medicines, pets, ornaments, building and construction materials all over the world. However, in many parts of East Africa, the trade patterns of these products are inadequately documented, making it difficult to build good strategic management and long-term conservation plans. The Ruaha landscape in southern Tanzania is home to a potential animal population and is one of the hotspot locations for wildlife trade. The purpose of this research in the Ruaha landscape was to (i) assess the wildlife poaching practices (ii) to assess the temporal variation of illegal hunting and (iii) Map illegal trade flow of wildlife products and facilitation methods in the Ruaha landscape Tanzania. A semi-structured interview was conducted using the Snowball method to gather the necessary information. The data was analysed using Chi-square tests, Social Network Analysis (SNA), and Generalized Linear Models (GLM) with Poisson and Binomial error distributions. Impala, did-dik, guinea fowls, kudu, and lions were found to be the most hunted species, and meat, skin, claws, fat, and ivory were the most often collected wildlife products. The majority of the products were utilized for food and as sources of revenue. Domestic dogs, spears, snares, and torches were found being used in hunting and this was frequently being done at night. Occupation, ethnic group, religion, residency time, number of individuals participated in each hunt, presence of moonlight, age, and education of respondents were the factors influencing the hunting. However, during the last five years, the overall tendency revealed a drop in hunting, while animal protection in protected areas increased. According to the findings, 70% of the wildlife products came from Ruaha National Park and MBOMIPA Wildlife Management Areas, with the other 30% coming from villages near these protected areas. Bicycles and walking were the primary modes of transportation for wildlife products. In addition, the findings suggest

that respondents have long and deep relationships with their clients and merchants, the majority of whom are friends and relatives. It was also shown that the majority of poachers are motivated to engage in illegal wildlife trafficking by their friends and relatives. Furthermore, in circumstances where customers and sellers lacked cash, commodities such as corn and rice were traded for wildlife products. When it comes to illegal wildlife hunting the findings of this study provide critical information on the importance of taking species and ethnic group peculiarities into account. Wildlife protection, such as day and night patrols, is critical, particularly at night. In order to address illegal wildlife hunting in this landscape, sociological aspects must be taken into account. Increased law enforcement could have a positive impact on the declining trend of wildlife hunting. As a result, it is suggested that providing conservation education, in combination with an employment, may help to reduce illegal wildlife product off-take in the Ruaha landscape.

DECLARATION

I, Hillary Thomas Mrosso, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

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To all, I say be blessed.

DEDICATION

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LIST OF ABBREVIATION AND ACRONYMS

CITES	Convention on International Trade in Endangered Species of Flora and Fauna
GLM	Generalized Linear Models
GRRE	Great Ruaha Rungwa Ecosystem
MBOMIPA	Matumizi Bora ya Malihai Idodi na Pawaga
NBSAP	National Biodiversity Strategy Action Plan
OECD	Organization for Economic Co-operation and Development
PI	Principle Investigator
SNA	Social Network Analysis
SUA	Sokoine University of Agriculture
TNRF	Tanzania Natural Resources Forum
UNEP	United Nations Environment Programme
UNODC	United Nations Office on Drugs and Crime
URT	United Republic of Tanzania
USAID	United State Agency for International Development
WCMC	World Conservation Monitoring Centre

CHAPTER ONE

1.1 GENERAL INTRODUCTION

1.2 Background information

To many people, wildlife signifies different things. Nonetheless, numerous publications clearly state that wildlife refers to any wild or native animal or plant, as well as their natural surroundings, both terrestrial and aquatic (Roe, 2002; Gunvant *et al.,* 2015; URT, 2009). Wildlife species and their derivatives have been widely employed for a variety of reasons, including food, medicine, clothing, decorations, building materials, and as part of cultural, religious, and traditional rites, since the beginning of human history on this planet (Adeola, 1992; Angela *et al*., 2012; Gunvant *et al*., 2015; Vliet *et al.,* 2016). Currently, the globe is witnessing the exploitation of wild animal resources, which has resulted in a global decline in the population of wildlife species in the places where these products are gathered (Fa *et al.,* 2015; Knapp *et al.,* 2017; van Velden *et al.,* 2018).

Any component of a wild animal's body, such as horn, ivory, tooth, tursh, bone, claw, hoof, skin, meat, hair, feather, egg, and or other portion of any wild animal, as well as manufactured trophy or products, can be used as wildlife products or trophy (Barnett, 2000; URT, 2009; Lindsey *et al*., 2013). The rising demand for these items puts enormous strain on their ecosystems and contributes to biodiversity loss in every corner of the world where these resources are found (Fa *et al.,* 2015; Symes and Carrasco, 2018). There is evidence of widespread use of wildlife products for food, medicines, clothing, ornaments, or decorations, religious emulates, fuel, building and construction material, and the list is growing each year (Roe, 2002; Kitzes *et al.,* 2017; Wong, 2017), which encourages illegal wildlife harvesting and trade on the black market in particular (Roe, 2002; Wong,

2017). According to Vira *et al.* (2014), the presence of black markets in African, Asian, American, and European countries has stimulated the harvesting of wildlife species in many countries, and the sophistication of technologies and transportation routes has facilitated trade, import, export, and re-export of wildlife products from one place to another in a short period of time without being detected by enforcement authorities. (Wyler, 2013; Wong, 2017; Symes *et al.*, 2018). As a result, the rising use of wildlife products at the local, regional, and international levels is linked to the prevalence of both legal and illicit trade and black markets.

Illegal wildlife trade is a multibillion-dollar industry that includes the illegal harvesting and trafficking of wild animals and plants, as well as their products (Erosion, 2014; Symes *et al.*, 2018). According to reports, the Democratic Republic of China has a significant demand for ivory and rhino horn, which is used for a variety of purposes including traditional remedies, ornaments, and decorations. (Bennett, 2014; Vira *et al.*, 2014). In the majority of cases, Asian countries are claimed to be the primary source and destination of wildlife products such as ivory, rhino horns, live animals, and other wildlife products (Vira *et al.,* 2014; Wong, 2017). From the harvesting site to the destination, these products are traded, transported, and exported via highly intricate and sophisticated pathways and networks (Vira *et al.,* 2014; Fa *et al.,* 2015). Bribes, insufficient inspection equipment, and lesser possibilities of getting identified by law enforcement officials have all been highlighted as ways to influence the developing markets for wildlife products and promote the illicit harvest and sale of wildlife species in various source nations (Vira *et al.,* 2014).

In regions where these resources are available, the products serve an important role in sustaining and supporting the economy of many households (Angela *et al.,* 2012;

Oldfield, 2014; Samwel, 2017). People who live close to wildlife resources are linked to poaching and encroachment (Barnett, 2000; Lindsey *et al.,* 2013; Wilkie *et al.,* 2016). Many local and international laws and regulations make it illegal to hunt or possess wildlife products unless you have a permit (URT, 2009; Symes *et al.,* 2018). Despite the existence of sustainable hunting laws and regulations in many countries, illegal hunting is on the rise, indicating that these laws and regulations have failed to accommodate and benefit the majority of poor people who live beside these resources (URT, 2009; Picard, 2015). In such circumstances, most protected areas are threatened not only by the loss of valuable biodiversity that is important ecologically, economically, and traditionally or culturally, but also by the spread of viruses that are harmful to the health of humans, domestic animals, and wild animals (Symes *et al.,* 2018). According to studies, increasing uses and trading of wildlife products is a result of a variety of issues including poor enforcement, protein scarcities (Angela *et al.,* 2012; Bachmann *et al.,* 2019) dishonest game personnel (Kidegesho, 2016) spiritual requirements (Adeola, 1992; Coal *et al.,* 2020), lack of wildlife benefits, human population growth (Kidegesho, 2016), and as an alternative source of income (Lindsey *et al.,* 2013; Kitzes *et al.,* 2017; Samwel, 2017). As a result of these reasons, many parts of Africa, including Tanzania, are witnessing a similar situation of illegal wildlife products being consumed and exchanged by the majority of people who live near protected areas (Clarke and Babic, 2016; Kitzes *et al.,* 2017; Knapp *et al.,* 2017; Coal *et al.,* 2020).

People's reliance on illicit hunting, trade, and consumption of wildlife items is exemplified by studies from various sections of Tanzania (Angela *et al.,* 2012; Bitanyi *et al.,* 2012; Mgawe *et al.,* 2012; Ceppi and Nielsen, 2014; Knapp *et al.,* 2017; Coal *et al.,* 2020). For instance, Magige (2015) found that small animal products such as blood, fur, bones from African savannah hare (*Lepus nicrotis*), spine, fats, faecal pellets, and skin

from porcupine (*Hystrix cristata*) and rock hyrax (*Procaniviacapensis*) were widely used in traditional medicines to treat stomach pain, diarrhoea, convulsions, and bleeding nose in the Serengeti District. Similarly, populations in the Udzungwa Mountains and the Tarangire-Manyara habitat, use wild meat as an alternate protein source, and poverty is cited as a major factor motivating illegal wildlife hunting for daily survival (Angela *et al.,* 2012; Bitanyi *et al.*, 2012; Nielsen, 2006; Kniffer *et al.*, 2015; Rija, 2022). Furthermore, pangolin products including as scales, claws, and blood are widely used for spiritual, religious, and therapeutic purposes among Tanzanian ethnic groups, as evidenced by Hehe, Sangu, and other pastoral communities (Walsh, 1995; Clute *et al.,* 2017). Furthermore, a recent study in the Ruaha landscape revealed illicit hunting and pastoral communities' traditional uses of wild animal derivatives (Knapp *et al.,* 2017; Coal *et al*., 2020). As a result, the widespread use of wildlife products, combined with illegal hunting has considerably contributed to the decline of wildlife species and their natural habitats in many places of the world including Tanzania.

1.3   Problem statement and justification

Tanzania is among the mega-biodiverse country in the world (Majamba, 2000; URT, 2007). However, its resources are under pressure due to illegal off-take of wildlife resources (Jambiya *et al.,* 2007; Ceppi and Nielsen, 2014). The increasing demand of wildlife products from domestic and international markets, catalyses illegal trade of wildlife and their products (Symes *et al.*, 2018; Fukushima *et al.*, 2021). According to the available literature, the principal illegal trade in the Ruaha landscape involves a few wildlife species such as lions, pangolins, and elephants, as well as their products (Knapp *et al.*, 2017; Clute *et al.,* 2017; Mkuburo *et al.,* 2020; Coals *et al.,* 2020). Wildlife products have been taken officially through trophy hunting and illegally through poaching

in the Ruaha landscape, which encompasses the study areas of Idodi and Pawaga divisions (Knapp *et al.*, 2017).

Similarly, other available studies focused on human carnivores' conflicts, distribution of carnivore species and drives of poaching (Knapp *et al.,* 2017; Abade *et al.,* 2018; Kalyahe *et al.,* 2022; Kimaro *et al.*, 2022). Despite the baseline information from the past studies, very little is known about other wildlife species and their products involved in illegal trade. Also, there are limited studies considering the temporal variation of illegal hunting and flows of wildlife products between villages, wards, divisions, districts and regions. The creation of effective mitigation measures against illegal wildlife trafficking at the national, regional, and intercontinental levels is hampered by a lack of this critical basic information. As a result of this need, this study attempted to fill the knowledge vacuum by analysing the trade flow of wildlife products from the Ruaha landscape. The findings of this study will help protected area authorities, law enforcement, and the government, particularly the Ministry of Natural Resources and Tourism, focus their efforts on managing wildlife trade and illicit activities in the Ruaha landscape and other parts of the country. In addition, it provides crucial data for future research on the legal and illegal trafficking of wildlife species.

1.4   Objectives of the study

1.4.1   General objective

The general objective of the study was to assess the trade flow of wildlife products from Idodi and Pawaga divisions in the Ruaha Landscape in Tanzania.

1.4.2   Specific objectives

The specific objectives of the study were to:

i.   Assessment of wildlife poaching practices in Tanzania's Ruaha landscape

ii.   To assess temporal variation of illegal hunting in Ruaha landscape Tanzania

iii. To map the illegal trade flow of wildlife products and facilitation methods in the
      Ruaha landscape, Tanzania

1.5   Research questions

The study was guided by the following research questions:

i.   Which wildlife products are traded in the villages of Ruaha landscape and what are
      they used for?

ii.   Which wildlife species targeted for illegal hunting?

iii. What is the origin of wildlife products (protected area (e.g. park) and unprotected
      area (e.g. village land)?

iv.   How often do people engage in harvesting wildlife products?

v.   What is the best time for conducting illegal hunting?

vi.   How much of the wildlife products is being traded?

vii. What are the methods used for illegal hunting?

viii. What transport facilities used to transport wildlife products?

ix.   Where is the destination of the wildlife products within and outside Tanzania?

1.6   Conceptual framework

Trade in wildlife products is the theme that is reported by numerous scholar journals,
books, reports and social media platforms. It has been reported that wildlife trade has
significant impacts on ecology, economic and in socio economic aspects (McEvoy *et al*.,

2019).   Due to this situation, it is important to look at the concepts of trade of wildlife products in this fashion as it is illustrated in (Figure 1). Both legal and illegal hunting of wildlife species not only influence the trade flow of wildlife products from one place to another   (Majamba, 2016) but also, bring changes in ecology by causing biodiversity loss and increase of invasive species. Economically, trade especially illegal will reduce the government revenue through commercial hunting, tourism activities and in social trade have impacts on the emergence of diseases.

Trade flow of wildlife products	
Illegal hunting wildlife	Legal hunting of wildlife

Ecological changes	
Poaching, enchrochment, retaliatory killing	Source of revenues, problem animal control, Science and research, wildlife population control

Impacts: Illegal trade, spread of diseases, wildlife population decreased	
Ilegal trade and use of wildlife products like meat, skin, fat, claw, scales, horn, ivory	Legal products like meat, skin, fat, claw, scales, horn, ivory

Flow and uses of wildlife products in villages, urban, towns, regions and in other countries

Figure 1: Conceptual Framework showing trade flow of wildlife products

1.7   Limitation of the study

a)   The goal of this research was to look into both legal and illegal wildlife products. Unfortunately, legal data on wildlife products from government agencies was difficult to get, particularly in the MBOMIPA WMA, where

tourism hunting took place. As a result, the data and analysis were based on illegal wildlife products and other associated data.

b) Because of the nature of the study, some respondents declined to participate in the interview because they believed they would be targeted by law authorities, resulting in limited data. This misunderstanding was cleared up by promising the respondents that the information would be kept private and used for academic purposes only.

c) The greater part of the respondents was working on their farms during the time of the study, which was done during the farming season. In order to circumvent this, interviews were conducted during non-working hours, particularly in the evenings, and they were occasionally followed on their farms, which were located far from their residences.

1.8   Dissertation structure

This dissertation has been written in publishable manuscript format following Sokoine University of Agriculture (SUA) new guidelines and regulations of 2021; which include an extended abstract, a general introduction, chapters based on manuscripts, a general discussion, a general conclusion, recommendations, and appendices.

Chapter One presents the general introduction of the study, which includes background information about illegal hunting and trade of wildlife products; problem statement and justification of the study; objectives; research questions; conceptual framework; limitations of the study; and the dissertation structure and references. The specific objectives of this study stand as separate manuscripts, and each manuscript has its own abstract, introduction, materials and methods, results, discussion, recommendations, acknowledgement, and references.

Chapter Two presents the first manuscript titled "Wildlife poaching practices in Tanzania's Ruaha landscape." This manuscript details the wildlife species involved in illegal hunting and their products' uses. It also presents the methods used by poachers to conduct illegal hunting of wildlife species in the Ruaha landscape. This manuscript has been submitted and accepted by the Tanzania Journal of Forestry and Nature Conservation for publication.

Chapter Three presents the second manuscript titled "Temporal variation of Illegal Hunting in the Ruaha Landscape". The manuscript details the rate of illegal hunting; the rate of people entering into the protected areas per week, month, and annually; temporal variation of illegal hunting such as time of the day and night; sociological factors such as age, education, occupations, tribes, religions, residence time, and presence or absence of moonlight influencing temporal hunting; and lastly, this manuscript analyses the trend of illegal hunting for the past 5 years in the Ruaha landscape, whether it has decreased or increased and its reasons. This paper has been prepared to be submitted to the International Journal of Biodiversity and Conservation.

Chapter Four presents a third manuscript, titled "Illegal trade: Trade flow of wildlife products and facilitation methods in the Ruaha landscape of Tanzania". This manuscript describes in detail all the villages involved in the trade flow of wildlife products; it shows the original and destination of wildlife products; the transportation facilities used by poachers to transport wildlife products from one place to another; it also analyzes the relationships that exists among hunters, traders, and customers. In addition, this paper analyzed the exchange category of wildlife products and other goods such as maize and rice. Finally, the motivation of people to engage in illegal hunting are analyzed and presented. This manuscript has been published in the Open Journal of Ecology in September, 2022. The last chapter (Chapter Five) of this dissertation presents the general

discussion, general conclusion, and recommendations. This section includes major discussion of key findings from this study and conclusions from each manuscript.

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CHAPTER TWO

First Manuscript

2.0 Wildlife Poaching Practises in the Tanzania's Ruaha Landscape

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Abstract

Throughout the world, millions of wild species and products are illegally collected, used, traded, exported, and imported. Poaching of wildlife species has been found to have substantial detrimental consequences for the ecosystem and community's livelihood. Tanzania's Ruaha landscape is considered a critical area for biodiversity, as well as an area where poaching exists. Despite the area being rich in abundance and diversity of wildlife, in-depth analysis of wildlife species hunted most and the methods used by poachers is lacking. This study assessed the most hunted wildlife species, extracted products and uses, and associations between wildlife products, hunting methods, and ethnic groups. Data was collected by utilizing the snowball technique after 123 poachers were given a semi-structured questionnaire in villages near the Ruaha National Park. Among the most hunted species are did-dik, impala, kudu, lion, buffalo, and elephants. Bushmeat, skin, claws, ivory, and fat were the most harvested wildlife products. Sixty percent (60%) of wildlife products used for food and source of income, and the methods used for illegal hunting were domestic dogs, spears, snares, and torches. The findings are critical for understanding the link between the most poached species, products, and methods used in relation to ethnic groups in the Ruaha landscape. Increased anti-poaching patrols and wildlife conservation awareness could help reduce the dependence of local communities on wildlife products.

Keywords: Ethnic groups, poachers, poaching methods, Ruaha landscape, wildlife products,

2.1   Introduction

Throughout the world, millions of wild species and products are illegally collected, used, traded, exported, and imported (Roe *et al.,* 2002; Janine *et al.,* 2018; van Uhm *et al.,* 2018).   Poaching of wildlife species has been found to have substantial detrimental consequences for the ecosystem and community's livelihood, including loss of biodiversity, an increase in illegal wildlife trafficking, and changes in land use (Ntiamoa-baidu, 2014; Kidegesho, 2016; Rija, 2022). And because poaching is not selective mainly because of the methods used in illegal hunting, the rate of declining of important species including those serve as an umbrella and keystone species is high (Loibooki *et al.,* 2002; Caro, 2003; Ibanga, 2017). For instance, elephants, rhinoceros, lions, tigers and pangolins are under the category of endangered species due to overuse of their body parts and trade (Vira *et al.,* 2014; Ibanga, 2017; van Uhm *et al.,* 2018; Challender *et al.,* 2020).   The miscellaneous uses of wildlife species not only influence illegal trade in these species but also creates demand for other less concern wildlife species in the trade flow like impala, kudu, giraffe, warthogs and zebra (Wilfred and Maccoll 2010; Ibanga 2017; Andimile and Floros, 2021).

The main variation of usage of wildlife products in many domestic and foreign marketplaces is monetary values, beliefs, myths, traditional remedies, and food. (Loibooki *et al.,* 2002; Erosion 2014; Wong, 2017). Any portion of a wild animal's body, such as horn, ivory, tooth, bone, claw, hoof, skin, meat, hair, feather, egg, or full body, can be used to make the so-called wildlife product (URT, 2009; Bennett, 2014). The majority of wildlife products are marketed and used in a variety of ways (Nijman *et al.,* 2019). Meat is used as food; skin, bones, teeth, and claws for ornamentation; while fat and other parts of the animal are used for traditional medicine and witchcraft (Adeola, 1992; Barnett, 2000;   Nijman *et al.,* 2019). Wildlife products are one of the world's largest

businesses projected to be treasured between $9 to 20US billion dollars per year due to many application including diet, treatments, furnishing, apparel, pets and spiritual items (Walsh, 1995; Reeve, 2002; Boakye *et al*., 2018; van Uhm *et al*., 2018), however, obtaining these wildlife items can be difficult depending on the location and law enforcement resources available (Lindsey *et al.,* 2013). As a result, poachers who are local communities have developed a wide range of hunting methods such as spears, bow and arrows, guns, poisons, traps, holes, and dogs in order to collect wildlife products like meat, skins, fat, ivory, bones and the whole animal body (Coppolillo, 2004; Gandiwa *et al*., 2014; Ogada, 2014; Samwel, 2017). According to Swamy and Pinado-vasquez (2014), the availability of indigenous and modern hunting tactics or methods, which are extensively exploited by poachers to hunt wildlife species, facilitates the escalation and demand for wildlife species and their products.

Poaching threatens the protection of wildlife species in Tanzania, as it does in many other African countries (Kidegesho, 2016; Nielsen e*t al*., 2016; Rija, 2022). The Ruaha landscape in Tanzania, where this study was conducted, is branded as one of the country's most important conservation areas, which is home to a diverse range of wildlife species (Dickman *et al.,* 2014; Abade *at el*., 2014; Strampelli *et al*., 2022), however, it is a landscape where poaching of wildlife species hotspots has been noted (Barnes and Kapela, 1991; Knapp *et al*., 2017; Beale *et al*., 2018). Much of the existing research in this area focuses on iconic species like elephants and lions (Beale *et al.,* 2018; Mkuburo *et al*., 2020; Coals *et al*., 2020; Strampelli *et al*., 2022). There is a scarcity of information about illegal wildlife products, their uses, and poaching techniques or methods used in the Ruaha landscape, particularly for several species. Therefore, this study bridges the existing knowledge and information gaps. The findings from this study are essential in supporting conservation efforts in the study area and elsewhere where similar issues exist.

2.2 Materials and methods

2.2.1 Description of the study area

Ruaha landscape covers about 43 000 km^2 and is composed of core Ruaha National Park, and the adjacent game reserves, game controlled area, wildlife management areas, and village lands (Strampelli *et al*., 2022). This landscape is abundant in wild species and diverse in its diversity (MNRT, 2011). Our research focused on 16 villages in Tanzania's Iringa district, at the southeast boundary of Ruaha National Park and adjacent to the Pawaga-Idodi Wildlife Management Area, which are part of the Ruaha landscape, ranging from 33.3º to 35.5ºE and from 5.7º to 8.7ºS (Fig. 2). These villages are located in the Pawaga and Idodi divisions and were chosen because of their history of poaching, as well as well they are less researched area for the poaching patterns, as indicated by the primary investigator and other recent studies that indicated illegal hunting of wildlife species in the area (Barnes and Kapela, 1991; Coppolillo, 2004; Knapp *et al*., 2017; Coals *et al*., 2020). The main economic activities across the 16 villages include pastoralism and crop cultivation (Dickman, 2009).
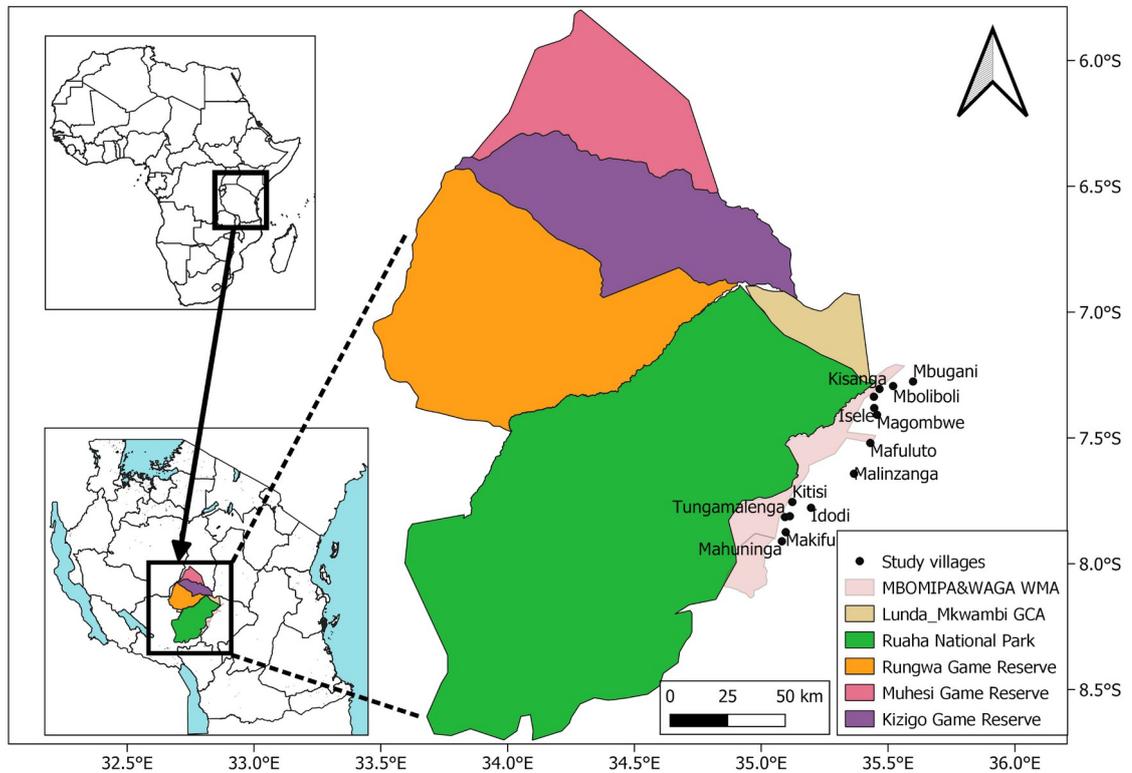
Figure 2.1: Map showing study area location and the villages where questionnaire interviews were conducted

2.2.2   Data collection

Each division (Pawaga and Idodi) had eight villages, each of which was divided into strata. A semi-structured interview guide was used collect primary data from poachers across the study villages, this information covered demographics, poaching experiences, preferred wildlife species, wildlife products involved, product uses, and wildlife hunting strategies. The sample was obtained from a list of people in the village who were known to be poachers, who then compiled a list of additional poachers in the area.

The majority of these poachers were men, as is usual in rural African communities (99%). A current weakness of this study is the lack of women's narratives on their poaching experiences, product use, and hunting techniques, which should be addressed in future research designs (Goldman *et al.,* 2021). Referral chain technique of which poachers helped to identify other poachers who would be willing to participate in this study (Bryman, 2008; Vo, 2020). This study did not interview wildlife officials from the government, and recognize that this present potential limitation of the understanding of the spatial and temporal poaching intensity in this landscape and the mitigation efforts that have been implemented. As a result, more research in this area is required.

Prior to beginning the interviews, each person was given a thorough explanation of the study, including how their identity would be secured and how their interview data would be used, and verbal free and informed consent from each participant was acquired. Participants were informed that they could opt out of the study at any moment and have their personal information erased. Participants were also aware that they had the option of refusing to answer any questions during the interview process. The interview was performed in Swahili by the primary investigator (PI) and participant replies were recorded in English. The PI was accompanied by an indigenous field assistant who assisted with the locating of participant residences. Each interview was conducted in a conversational fashion, which was more culturally relevant and helpful to put participants at ease.

2.2.3 Data analysis

Data cleaning was done using Microsoft Excel, and data analysis was done using R software (R Core Team, 2021). The Generalized Linear Model (GLM) was used to

quantify the variation in number of animals hunted between different species, while Fisher's test was used to assess the association between wildlife products and species involved.   The chi-square test was used to assess differences in product usage frequency. Mosaic analysis was performed to assess the correlation between wildlife products and ethnic groups. Furthermore, mosaic analysis was performed to assess the correlation between hunting methods and ethnic groups.

2.4 Results

2.4.1 Most poached wildlife species

The study found a significant variation in number of animals hunted between different species (GLM, χ^2 = 2935.7, DF = 3159, P < 0.001). Impala, dik-dik, kudu, guinea fowl, lion, buffalo and elephants were the most commonly hunted species (Fig. 2.2; full list of all species found in Appendix 3). This means that small and medium-sized wild animals are hunted more than large ones.
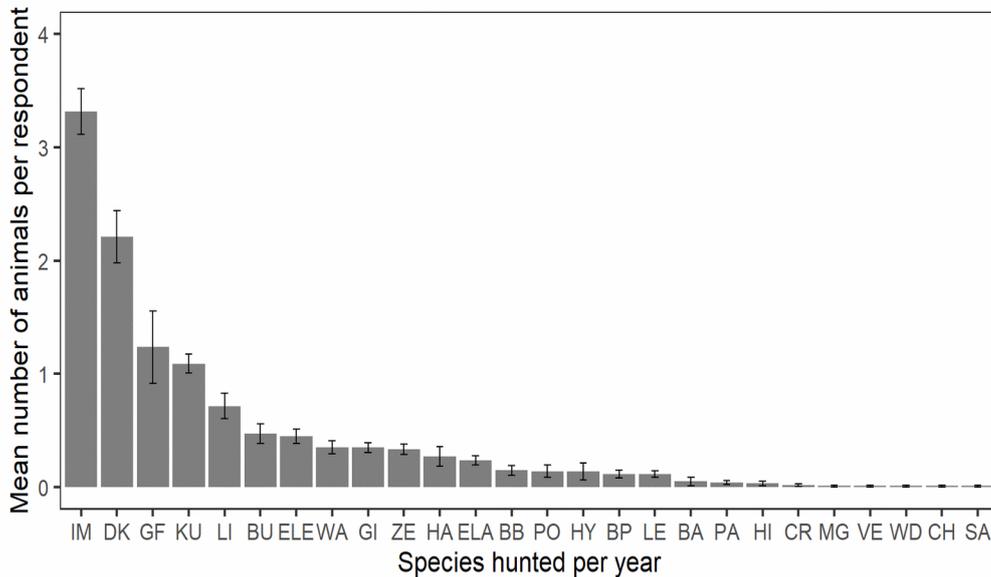
Figure 2.2: Number of species hunted per year

Key: IM: Impala; DK: Dik-dik; GF: Guinea fowl; KU: Kudu; LI: Lion; BU; Buffalo; ELE; Elephant; WA: Warthog; GI: Giraffe; ZE: Zebra; HA; Hare; ELA: Eland; BB: Bushbuck; PO: Porcupine; HY: Hyaena; BP: Bush pig; LE: Leopard; BA: Baboon; PA: Pangolin; HI: Hippopotamus; CR: Crocodile; MG: Mongoose; VE: Vervet monkey; WD: Wild dog; CH: Cheetah; SA: Sable antelope.

2.4.2 Wildlife products

A total of forty wildlife products were identified (Appendix 2), representing 26 species, including pangolin which is listed on CITES Appendix 1 as prohibited for trade (Appendix 4). To improve precision, the study concentrated on species that contributed to more than 5% of total counts. The warthog, lion, kudu, impala, giraffe, elephant, dik-dik, and buffalo were among the species with sufficient counts (more than 5%) for further analysis (Fig. 2.3). The findings demonstrate a strong association between most hunted species and wildlife products harvested (Fisher's test, $P < 0.01$). Bushmeat hunting appeared to be associated with all species (warthog, lion, kudu, impala, giraffe, elephant, dik-dik, and buffalo). Skin, claws, and fat associated more with lions, while ivory associated with elephants (Fig. 2.3).
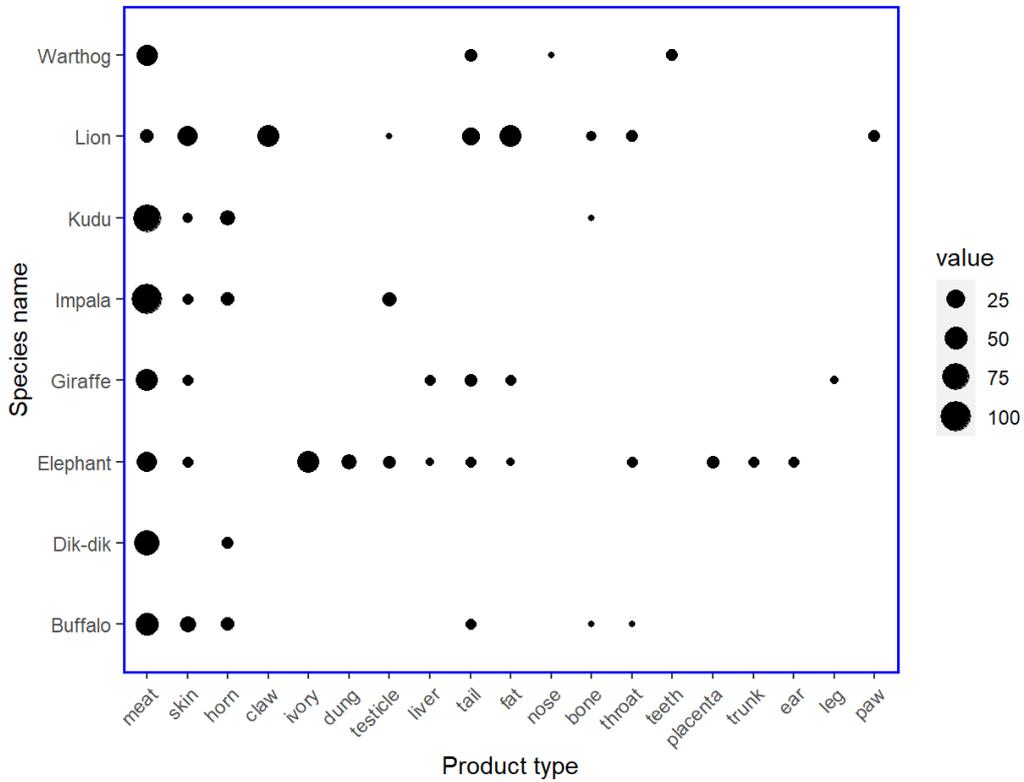
Figure 2.3: Frequency of Wildlife products for each species as reported by participants around the Ruaha landscape

2.4.3 Wildlife products use

The product use categories considered in this study had a substantial difference (χ^2 = 17.989, DF = 4, P = 0.001. The majority of respondents (60%) said they used wildlife products for food and as a source of income (Fig. 2.4). When these categories compared to each other, all pairs were significant (p < 0.05) except comparison between trophy and medicinal uses, trophy and spiritual uses, food and income uses, and finally between medicinal and spiritual uses (P > 0.05). The diverse use of wildlife products is found in the Appendix 4.
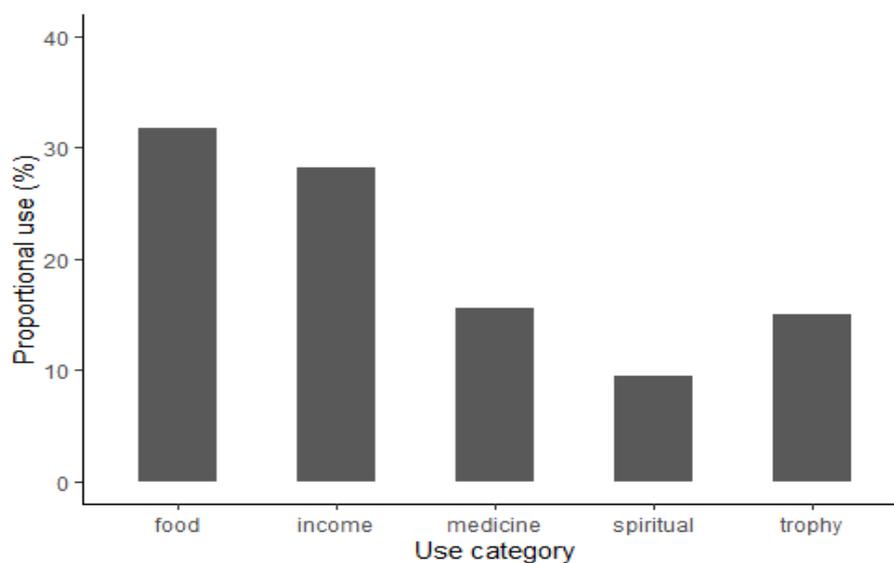
Figure 2.4: Percentage of wildlife products per use category

Table 2.1: Chi-square post hoc pairwise results derived to compare probability values of wildlife product categories as reported by respondents

Wildlife product comparison	P value
Trophy vs food	<0.01
Trophy vs medicine	1.00
Trophy vs income	<0.01
Trophy vs spiritual	0.39
Food vs medicine	<0.01
Food vs income	1.00
Food vs spiritual	<0.01
Medicine vs income	<0.01
Medicine vs spiritual	0.24
Income vs spiritual	<0.01

Further analysis suggested a link between wildlife products and ethnicity; however, ethnicity was found to have only a minor impact in the investigation (Fisher's test, P =0.07). Despite the minor overall association of ethnicity with wildlife products, on a fine scale the pastoral tribes particularly the Barabaing and Maasai had a strong positive

association with using wildlife products as traditional trophies. Whereas non-pastoral tribes, particularly the Hehe tribe, had a negative association with using wildlife products as trophies, preferring to use them as food and a source of income (Fig. 2.5). In comparison to other tribes, the Barabaing tribe has a stronger favourable connotation with the usage of wildlife products for spiritual purposes. Wildlife products were discovered to have various uses, with pangolin scales having more than other products (Appendix 4). This indicates that despite the fact that pangolins are not among the most hunted animals, their body parts, notably their scales, are widely used. Lion fats were another product shown to have several uses after pangolin scales (Appendix 4), showing that lion protection in the Ruaha landscape is critical.
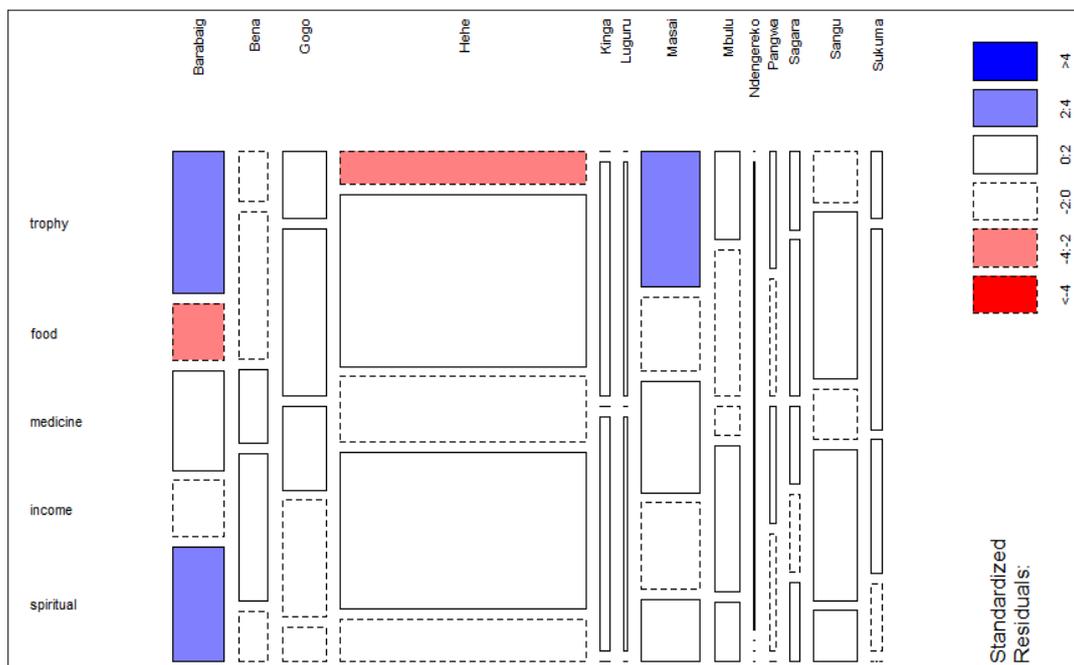
Figure 2.5: Association of wildlife product types and ethnic groups in the Ruaha landscape.

The colour indicates the degree and magnitude of association, in which the bright blue indicates a strong positive association, while bright red indicates a strong negative association.

2.4.4 Methods of hunting wildlife

According to the assessment into poaching methods, local poachers primarily utilize dogs, spears, snares, and torches included as an accessory to hunting tool (Fig. 2.6).
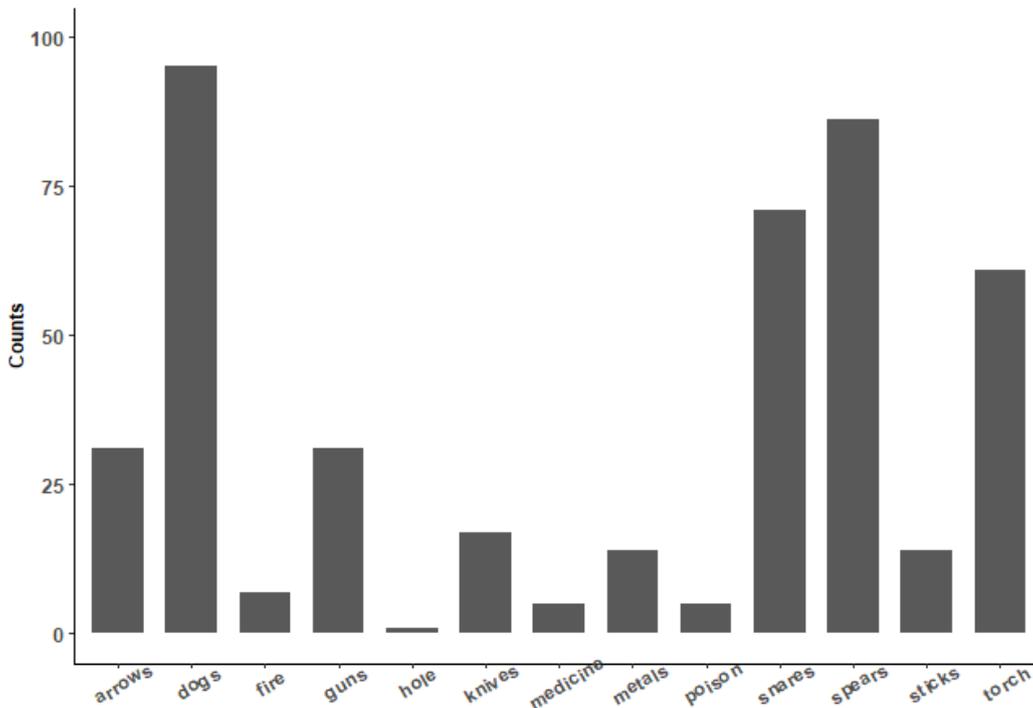
Figure 2.6: Hunting methods used by hunters for harvesting wildlife products in the Ruaha landscape

Assessments of the relationship between hunting methods and ethnicity, found that agro-pastoral tribes, particularly the Mbulu tribe, had a strong positive association with the use of snares and poison as their primary strategy for hunting wildlife (Fig. 7). Pastoral tribes, particularly the Maasai, have close ties to the usage of traditionally prepared organic poison for hunting wildlife, while the Sukuma tribe dug tunnels to capture animals (Fig. 7). As a result, hunting practices vary per tribe, which may aid in providing anecdotal evidence when examining wildlife mortalities and when addressing poaching issues.
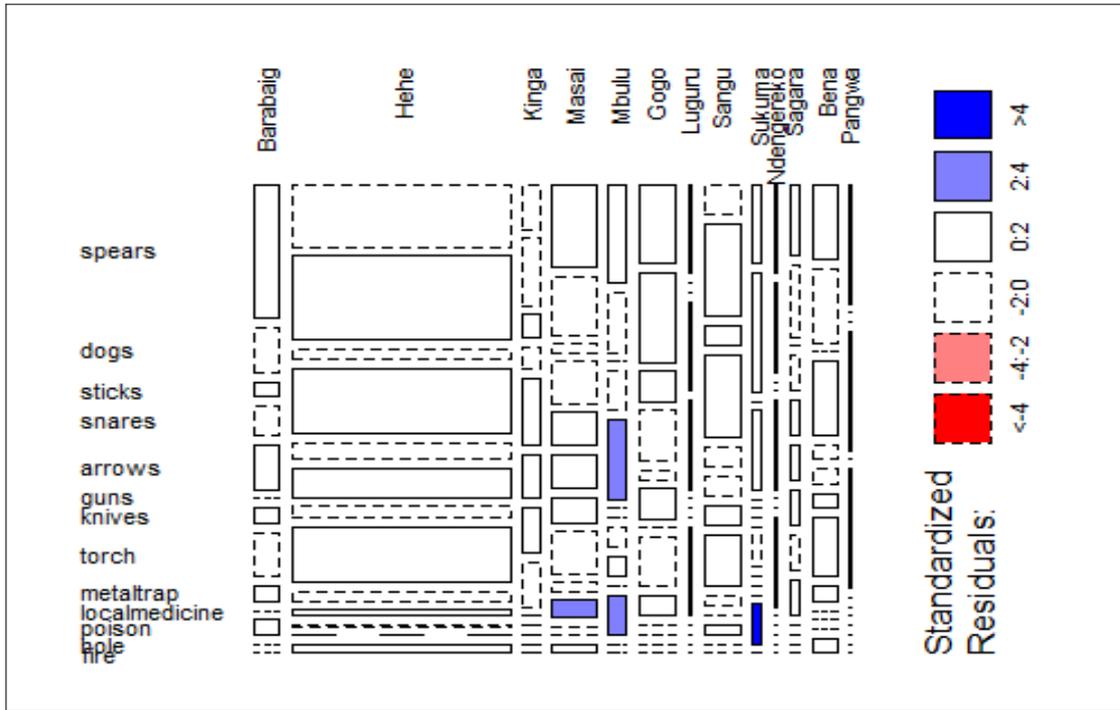
Figure 2.7: Relationship between hunting methods and ethnic groups in the Ruaha landscape.

The colour indicates the degree and magnitude of association, in which the bright blue indicates a strong positive association, while bright red indicates a strong negative association. Dashed bars indicates a negative association, while the solid bar indicates a positive association

2.5 Discussion

This survey used semi-structured interviews to gather information regarding the most hunted wildlife species, types of wildlife products and their uses, and the techniques used in illegal hunting in Ruaha landscape Tanzania. This study found that wild animals such as impala, greater and lesser kudus, dik-dik, giraffe, buffalo, lions and elephants and warthog were the most hunted species in the Ruaha landscape. Similar to the findings of Wilfred (2020), a comparable study by Setsaas *et al.* (2007) suggested that impala and other small mammals are widely poached in Ugalla Game Reserve and Serengeti National Park, also reported in other places in Africa (Goncalves *et al*., 2019; Andimile and Floros, 2021;   Rija, 2022).

The demand for wild meat is very high in Ruaha landscape (Knapp *et al.,* 2017) and it was also pointed out by the recent study in the Serengeti National Park that illegal hunting for meat influence the decline of large mammals like buffalo and topi (Samwel 2017; Rija *et al.,* 2020). The reason could be due to the high value and large content of meat; it was also considered the source of protein in many parts of African families (Barnett *et al.,* 2000). In the same cases, Caro (2017) and Wilfred (2020) found that lager mammals like a hippopotamus and African elephants were highly poached due to their meat and teeth in Katavi National Park and also widely reported in other places (Lindsay *et al.,* 2013; Kidegesho, 2016; Rija, 2017). Several studies in the Ruaha landscape and other places indicated the illegal killing of large carnivores like lions and hyenas for various reasons like traditional, spiritual, and commercial purposes (Dickman, 2010; Ogada, 2014; Coal *et al.,* 2020). The illegal hunting of wildlife species is very common in the Ruaha landscape as it was reported in other protected areas (Fa *et al.,* 2015). The diverse use of wildlife products is considered the reason for the high harvesting of these wildlife species in the Ruaha landscape.

The analysis of wildlife products demonstrates a strong relationship between most hunted species and wildlife products harvested, implying that products often reported by poachers are from the most hunted animal species. This corresponded to the study conducted in Ugalla Game Reserve which found similar results (Wilfred, 2020). Wild meat appeared to be the most wildlife products obtained from these species similar to the findings of Wilfred (2020). Here in the Ruaha landscape, the found a total of 40 different wildlife products from 26 species like meat, skin, claw, fat, tail, horn, ivory, trunk, teeth, excretes, bones, liver, intestines, placenta, hair, scales, hooves, nose, ear, paw, spine, legs, testicles, throat, etc. The illegal hunting for these products was not only observed in the Ruaha landscape alone (Coal *et al.,* 2020) but also Wilfred (2020) found that majority of

the poachers in Ugalla Game Reserve were arrested and confiscated some similar wildlife products as mentioned in the Ruaha landscape (Adeola, 1992; Boakye *et al.,* 2018; Nijman *et al.,* 2019). The demand for wildlife products continue to increase globally and its impact is widely experienced in decline of most important species like elephants, rhinoceros, lions, tiger, pangolins, and some primate species (Vira *et al.,* 2014; Soewu and Sodeinde, 2015; Wong, 2017; Rija *et al.,* 2020). Conservation strategies should put more effort in both source and destination of wildlife products, this could help to the reduce demand for wildlife products.

In the Ruaha landscape, this survey found diverse use of wildlife products mostly for food, income, medicines, trophy, and spiritual uses. Wild meat was the common product used by the majority as the food or source of protein supplements and as a commodity that generate income. Analysis suggested that more than 60% of the illegal hunting is targeted for obtaining wild meat which is almost relevant to the findings of Mgawe *et al.* (2012) suggested more than 71% of the wild meat is hunted for food and income in the Katavi ecosystem. In line with this, a current study by Wilfred (2020) revealed more than 50% of the confiscated wildlife products were meat and was commonly used for a similar purpose. However, the previous study by Merode *et al.* (2004) found that there is high 90% dependence on wild resources especially meat by the majority of the people in the Congo DRC. Wild meat is sold extensively at the village levels and in some cases exported to urban or towns (Jones *et al.,* 2019; Andimile and Floros, 2021). This research found that, wild meat is widely consumed and secretly sold within the villages, and in some cases, it can be exported to town to the specified customers as pointed out by previous studies (Lindsey *et al.,* 2013; Jones *et al.,* 2019; Ceppi and Nielsen, 2014; Samwel, 2017; Fukushima *et al.,* 2021). This implies that wild meat is not only considered as an important source of protein but also a major alternative source of

income. In other cases, some respondents claimed that they will not stop illegal hunting and consuming wild meat because it is part of the inherited culture and their forefathers were hunting in the Ruaha landscape. This could have suggested that bushmeat consumption and the use of other wildlife products is engraved in traditional and cultural beliefs in many African communities (Walsh, 1995; Barnett, 2000; Clute *et al*., 2017; Bachmann *et al*., 2019;   Coal *et al*., 2020). The finding is also consistent with the study conducted in Serengeti National Park which denoted the consumption of Topi (*Damaliscus lanatus*) meat as a source of protein and income activity (Angela *et al.,* 2012; Samwel, 2017). However, the study found a strong association between the use of wildlife products and the ethnic groups in the Ruaha landscape. The findings suggested that pastoralists were more strongly associated with possession of wildlife trophies than other tribes.

Further analysis revealed the extensive uses of wildlife products for medicines, (trophy) decoration, and spiritual. The use of wildlife products for medicine, spiritual and as the trophy is consistent with other previous studies in Ugalla (Wilfred, 2020), Serengeti (Samwel, 2017), Katavi Rungwa ecosystem (Mgawe *et al*., 2012; Caro, 2017) and western Africa (Adeola, 1992). For instance, the majority of the respondent admitted to using skin, bones, fat, paws, tail, throats, and teeth of lions and leopards as traditional medicines to cure various ailments in children and adults, moreover, these parts are used as protection and chasing away evil spirits (Appendix 4). In several parts of Africa, the skin of lions or leopards is used as a symbol of power and authority (Adeola, 1992; Barnett, 2000), in Eastern Africa, these products are considered medicines and as an item of earning money (Dickman, 2009; Coal *et al*., 2020). The case is very different in Asian and European countries like China, Vietnam, and Thailand these products are wide luxury products and used to manufacture clothes, and shoes (Lindsay *et al*., 2013; Wong, 2017).

The previous studies the on illegal trade of wildlife products indicated China and other Asian countries were the big consumers of wildlife products especially elephant ivory, rhino horns, tiger bones, and pangolin products like scales and meat (Symes *et al.*, 2018; Lee *et al.*, 2019). This results suggested that, there are widespread use of wildlife products local, national and international levels. This could cause pressure on the conservation and management of other wildlife species and largely contributed to extinction of wildlife species. Therefore, urgently needs a conservation plan for the future of the remaining population of wildlife species in this landscape is needed.

Furthermore, the study revealed the commonly uses of dogs, spears, snares, and torches as methods of illegal hunting in the Ruaha landscape. The majority of the respondent in this landscape admitted to using those methods because are available and are less expensive compared to other methods like guns. However, Merode *et al.* (2004), Mgawe *et al.* (2012), and Knapp *et al.* (2017) reported that the majority of poachers use guns followed by wire snares to hunt wildlife species. Several studies in the Serengeti ecosystem reported wire snares as the most used methods for illegal hunting (Campbell *et al.*, 2001; Knapp, 2012; Bitanyi *et al.*, 2012; Lindsay *et al.*, 2013) but here in Ruaha domestic dogs were mostly used as hunting gear for the majority of poachers. This implies that there is a geographical variation in using hunting methods. Any uses of these methods pose detrimental effects on the wildlife population since some of these methods are non-species selective such as wire snares (Bitanyi *et al.,* 2012; Lindsay *et al.,* 2013; IUCN, 2018), pitfall traps, poisoning, and dogs (IUCN, 2018; Wilfred, 2020). These results in the Ruaha landscape contradict that of Knapp and others (2017) who reported that the majority used guns followed by snares and arrows, while this finding suggested that dogs were mostly used as hunting gear followed by spears, snares, and torches. Although there are slight differences, further analysis shows that the use of spears is consistent in both

studies. And also it was reported by other studies in the area that spears are responsible for declining of many wildlife species especially large carnivores (Dickman *et al*., 2014; IUCN, 2018; Coal *et al*., 2020).

Moreover, this research found an ethnic variation in the hunting methods, generally, spears and poisons were commonly used by agro-pastoralists and pastoral communities like Maasai and Barbaig (Dickman *et al*., 2014; Coal *et al*., 2020). While Hehe and other non-pastoralist are strongly associated with using dogs and torches in illegal hunting of wildlife species in the Ruaha landscape. These findings suggested that hunting practices vary per tribe, which may aid in providing anecdotal evidence when examining wildlife mortalities and when addressing poaching issue.

2.6 Conclusion

This study found that impala, dik-dik, kudu, lions, buffalo, warthog, and elephant to be the most hunted wildlife species in the Ruaha landscape. Analysis revealed that most hunted wildlife species were associated with their wildlife products. And bushmeat obtained from these wildlife species found to be most used products, followed by skin, fat and claws from lions and ivory from elephants.

The study found diverse use of wildlife products in the Ruaha landscape, majority, more than 60% claimed to use wildlife products as food and as source of income. Further analysis revealed ethnic variation of using wildlife products. Non pastoral communities like Hehe were used wildlife products as source of food and income while pastoral communities used wildlife products mainly for traditional trophy, medicines and as spiritual items. This suggested that the use of wildlife products is extensive in the Ruaha landscape.

The increasing illegal hunting in the Ruaha landscape was associated with the use of diverse technique of hunting. Domestic dogs, spears, snares and torch ware commonly used methods in illegal hunting of wildlife species. However, ethnic variation illegal hunting methods was observed for instance, non-pastoralist tribes like Hehe, Sukuma, Bena used domestic dogs, snares and torch while Maasai and Barabaing are strongly associated to use spears in conducting illegal hunting of wildlife species in the Ruaha landscape.

2.7 Recommendation

More research is needed on the population size of the most hunted species especially small and medium sized mammals is required in order to determine the remaining population of these species in the Ruaha landscape. Consequently, increasing conservation awareness and educational programs followed by effective anti-poaching patrols could help to reduce the dependence and widely use of wildlife products in the Ruaha landscape. In addition, when tackling illegal poaching in the Ruaha landscape, there is a need to consider ethnicity variation among the communities living near protected areas.

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CHAPTER THREE

Second Manuscript

3.0 Temporal Variation of Illegal Hunting of Wildlife Species in the Ruaha Landscape, Tanzania

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Abstract

Escalation of illegal wildlife hunting has been one of the biggest challenges facing conservation today. Ruaha-Rungwa ecosystem is amongst the largest ecosystems in the world, and is experiencing high level of illegal hunting of wildlife species. Factors underpinning illegal hunting in this ecosystem are not well documented. By using semi-structured, face-to-face interviews, this study explored the rate of wildlife hunting, temporal variation of illegal hunting, drivers underpinning temporal variation of wildlife hunting, and trends of hunting over the past 5 years. Generalized Linear Models with Poisson and Binomial error distributions were used for analysing the collected data. Most hunters reported to go for hunting twice per week, and most hunting occurred at night. The rate of hunting was mostly associated with occupation, ethnic group, religion, residence time, number of people involved per hunt, presence of moonlight, age, and education of respondents. The general trend of hunting rate decreased over the past 5 years, and increased protection of wildlife in the protected areas and the village lands were the main reason of such decline. Protection of wildlife is important especially during the night-time. Addressing illegal hunting of wildlife in this landscape require consideration of social factors underlined the problem. Increased law enforcement can bring promising results on the declined trend of hunting rate of wildlife. This study provides scientific suggestions required to consider when addressing illegal hunting of wildlife, and is can be applied in other parts of protected areas.

Keywords: Illegal hunting, protected areas, trends, underpinned, wildlife

3.1 Introduction

The dwindling of wildlife species is globally and locally emphasized to be one of the threats facing many protected areas in the world (Lindsey *et al*., 2013; USAID, 2017; van Velden *et al*., 2018). In line with other salient factors such as habitat destruction (Jambiya *et al*., 2007; Kidegesho, 2016), climate change (Kangalawe *et al*., 2015), increased human population (Kidegesho, 2016), wildlife trade (Symes *et al*., (2018; van Velden *et al*., 2020), and outbreak of invasive species (Lindsey *et al*., 2013; Symes *et al*., 2018;); illegal hunting of wildlife species is in the list of threats to wildlife and protected area conservation (Lindsey *et al*., 2013; Kidegesho, 2016; van Velden *et al*., 2018). Their effects not only hinges on the wildlife ecology, but also in economy and other social aspect of wellbeing of humanity (Clifford *et al*., 2013; Clarke and Babic, 2016; Symes *et al*., 2018).   The prominence of illegal hunting has been illuminated by several causes and it shows that no one reasons could be able to explain its complexity (Lindsey *et al*., 2013; Ceppi and Nielson, 2014; van Velden *et al*., 2020). However, most shared were noted as poverty and food uncertainty (Lindsey *et al*., 2013; Angela *et al*., 2012; Jones *et al*., 2019; van Velden *et al*., 2020); cultural and fame (Coal *et al.,* 2020) unemployment (Lindsey *et al*., 2013), level of protection (Mgawe *et al*., 2012; Ceppi and Nielsen, 2014), and distance from protected areas (Barnett, 2000; Mgawe *et al.,* 2012; van Velden *et al*., 2020). These reasons demonstrated the rate and frequencies of illegal hunting in various protected areas in the world.

Studies on bushmeat consumption and illegal hunting suggested diverse means that influence rate of people to engaged in illegal hunting (Lindsey *et al*., 2013; Jones *et al.,* 2019). A comparative study by Ceppi and Nielson (2014) reported the tribes' variation of bushmeat consumption per year and it put forward that the minimum consumption of meat is once per week. Further observation cited that, in grassland, it is estimated a single

person can consume about 15.2kg of meat in a year (Brown, 2003) while in the grassland forest it was estimated to be 9.7kg per year, and in the forest is 7.8 kg per year while in island the consumption of wild meat per year per single person is 22.7 kg (Brown, 2003: Nasi and Vliet, 2020). On the other hand, rate of illegal hunting is catalysed by wildlife trade, specifically illegal trade of wildlife products (Shanee, 2015; Far *et al*., 2015; Symes *et al*., 2018), for case in point, the United Nations Office on Drugs and Crime (UNODC) reported huge wildlife products transported from African and Asian countries which include 75 tons of ivory, 800kg of rhino horns, 500 skins and 1500kg of tiger parts (UNODC, 2011; Symes *et al*., 2018). The increased demand in local and international markets for wildlife products poses more threats to wildlife species and increases the speed of unsustainable hunting.

The illegal hunting of wildlife species reported to dominates in areas of weak anti-poaching protections (Wong, 2018: Thomas-waters *et al*., 2020). However, more cases of illegal hunting were reported in areas of active wildlife protection poverty (Wong, 2018: Fa *et al*., 2015; Thomas-waters *et al*., 2020). This is due to the temporal variation of illegal hunting of wildlife species. For instance, it was reported that high illegal hunting of wildlife species is conducted during the rain seasons (van Velden *et al*., 2020), because of less patrol during this wet seasons (Lindsey *et al*., 2013), while others suggested that illegal hunting is common during the dry seasons, due to the reason that during this time is easy to locate wildlife in water resources, shade areas, or areas of green blooms (Lindsey *et al*., 2011; van Velden *et al*., 2020). Further observation revealed that illegal harvesting and shipment of timber and other forest products was conducted during the night in the Amazon forest (GREENPEACE, 2014). While similar scenario was experienced in the Serengeti National Park Tanzania, involving conducting illegal hunting during the night and during crop harvesting and livestock grazing (Holmern *et al*., 2007;

Lindsey *et al.*, 2013). Although, these factors accounted for the declining of wildlife populations, it was rarely found the inclusion of time variation of day and night in illegal hunting except few sentence presented by Lindsey *et al* (2013). This means that there is a need to understand and quantify the exact time of the day that illegal hunting is conducted in other places of high biodiversity like the Ruaha landscape Tanzania.

Time variation or temporal variation of illegal hunting will clearly have understood if incorporated the trends and social demographic factors (Ceppi and Nielsen, 2014; Knapp *et al.,* 2017). This is important because, number of individuals in the households, ethnicity, education, age, wealthy of the family and religious conviction could have effects when examining illegal hunting (Mgawe *et al.*, 2012; Ceppi and Nielsen, 2014; Bachmann *et al.,* 2019; Coal *et al.*, 2020). The aforementioned studies stressed that these factors are significant when subjected to the equation of illegal wildlife hunting. This advocated that the use and demand for wildlife products is extensive. For instance, Barnett (2000) stated that more than 50 to 90% of the people living in Western Serengeti and Meatu District depend on wild meat for their protein supplies; and the similar case was noted in the protected areas found in the North-western Tanzania (Jambiya *et al.*, 2007; Lindsey *et al.*, 2013). These put forward that in areas with rich and diverse wildlife, population can be threatened with the illegal offtake of wildlife products. In this case, Ruaha landscape found in Tanzania offers a relative case study for this work. The existing reviews were focused on the distribution of wildlife species (Abade *et al.*, 2014; Kimaro *et al.*, 2022) human wildlife conflicts (Kalyahe *et al.,* 2022), and the socio-economic factors influencing illegal harvesting (Knapp *et al.*, 2017). These studies examined the crucial topic relating wildlife and their interaction with human. Nevertheless, detailed evidence on the temporal variation on illegal hunting is less documented which hinder the proper strategies for curbing the illegal hunting in this landscape. Therefore, this study

explored the rate of wildlife hunting, temporal variation of illegal hunting, drivers underpinned temporal variation of wildlife hunting, and trend of hunting in the Ruaha landscape.

3.2   Materials and methods

3.2.1   Description of the study area

The Ruaha landscape located in 6° 4'900" to 8° 20' 900" S and 33° 20' 900" to 35° 50' 900" the southern central Tanzania covers approximately 20,000 squares miles (Kimaro *et al.*, 2022; Strampelli *et al.,* 2022). This landscape represents complexities of abundances and richness of plants and animals which play significant ecological and biological functions within these ecosystems (Abade *et al.*, 2014; Kimaro *et al.,* 2022). In this landscape, lies second largest national park in Tanzania, the Ruaha national park 20,226km^2, MBOMIPA Wildlife management area, some game reserves and game controlled areas (Dickman, 2008; Kalyahe, 2013; Abade *et al.*, 2014). This zone is characterized by semi- dry and arid climatic conditions which influence the variations of vegetation communities of Sudanian savannah and Zambezian miombo woodlands and other acacia species, commiphora species and combretum species (Abade *et al.*, 2014; Kalyahe *et al.*, 2022). This region received average annual rainfall 500mm from December and January, March and April with average temperature range between 15 to 35C (Clifford *et al.*, 2013; Kimaro *et al.*, 2022). Moreover, the presence of the great Ruaha river is crossing within the park and become most important source of water to wildlife species especially during the dry seasons (Kimaro *et al.*, 2022). These unique features make this landscape considered of international important for supporting, conserving and holding abundant of wild species like lions, leopards, cheetah, wild dogs, elephants, buffalo, kudu, and diverse species of birds (Abade *et al.*, 2014; Kalyahe *et al.*, 2022; Kimaro *et al.*, 2022). In the other case, it is estimated that around 4000 km^2 of the

Ruaha landscape is comprised the village lands of which majority of the people are involved in agriculture and livestock keeping as their main social economic activities in this landscape (Dickman, 2008). This area not only named as the epicentre of human wildlife conflicts but is experiencing legal and illegal offtake of wildlife species from adjacent protected areas (Knapp *et al.,* 2017; Coal *et al.,* 2020). Therefore, Ruaha landscape is an outstanding area for investigating not only distribution and abundance of wildlife population but also how people interact with these massive wildlife resources existing in the Ruaha landscape. In this case, this area has been selected as a focal area for this study, specifically for villages in the Idodi and Pawaga division as shown in the figure below (Fig.3.1).
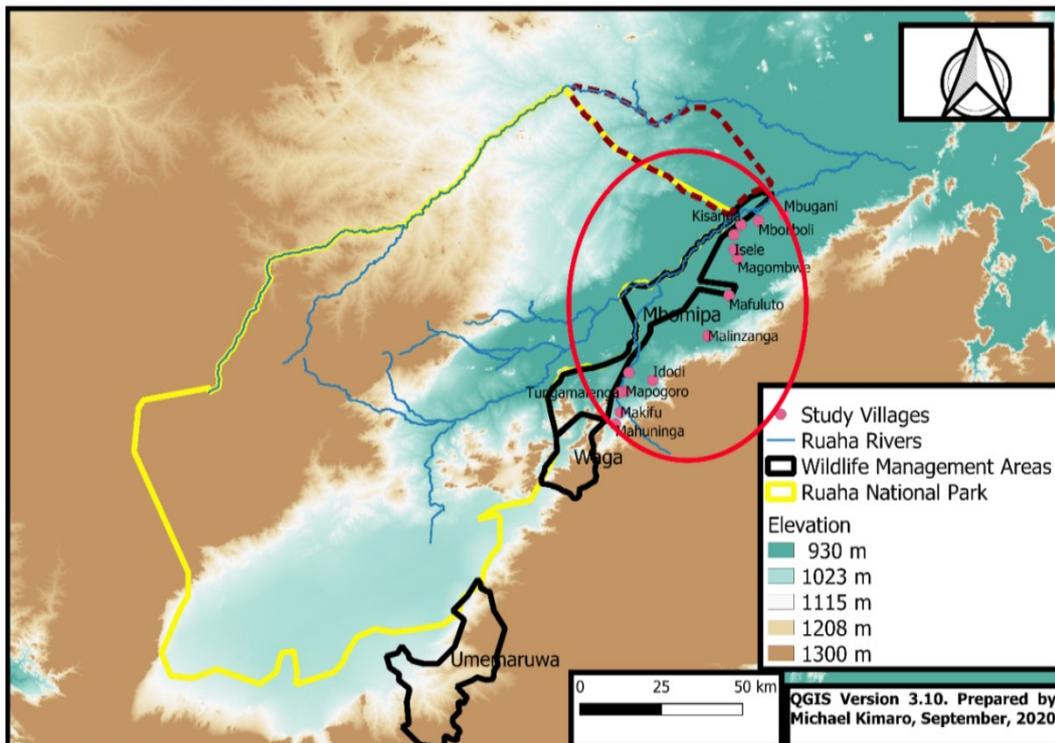
Figure 3.1: Map showing study area location. The red round (eclipse) shows villages where questionnaire interview will be conducted.

3.2.2 Data collection

Purposive sampling techniques were used to select villages and key informants in the study area. In both division Idodi and Pawaga, 8 villages in each division were selected purposively due to the assumption that villages close to protected area are involved in the uses and trade of wildlife products. A semi-structured questionnaire that was tested and refined with experts was used in collecting the required data. Snowball sampling technique was used to gather demographic data, rate of entering in the protected areas, time of conducting illegal hunting and trend of illegal activities for the past 5 years. A chain referral (snow ball technique) was applied by asking participants to provide additional contact names for new participants.

3.2.3 Data analysis

All analyses in this study were performed using R software (R Core Team, 2019). Chi-square test was used to assess differences on the frequency of hunting wildlife species. Generalized Linear Model (GLM), glm (Count ~ Time, family = poisson (link = log), the counts were treated as dependent variable while time of the day, occupation, age, religions, tribe and education were treated as independent variables with Poisson error distribution were used to analysed the drivers influencing the rate of hunting. In the same way, GLM used to assess temporal variation in hunting wildlife species. The posthoc test were used to find the difference in hunting time during the day, nights, and both day and nights

3.3 Results

3.3.1 Demographic information

This study interviewed 123 respondents of which majority were males (98.40%). Males were often mentioned due to their direct involved in the illegal hunting (Samwel, 2017). The tribe of the respondents were Hehe 45.53%, Maasai 9.77%, Gogo 8.13%, Barabaig

8.13%, Sangu 8.13%, Mbulu 4.88%, Bena 4.07%, Kinga 2.44%, Sukuma 2.44%, Sagara 1.63%, Luguru and Ndegeleko both represented 0.81% each. The main economic activities conducted in the study site were crop cultivation (66.90%) and pastoralism (13.7%), other identified activities were employment, crop and pastoralism (agro-pastoralist), pastoralism and crop cultivation together represents 3.20% of the respondents, on the other hand crop cultivation and employment represented 2.40%. About 77.40% of the respondents had primary education while 9.70% was identified to have informal education and others include secondary education 8.10%, certificate 1.60%, degree 1.60% and diploma 0.80%.

3.3.2 The rate of illegal wildlife hunting

Results indicated an insignificant difference on the wildlife hunting frequency (χ= 2.9231, DF = 8, P =0.9193). Although the findings were not significant, most respondents (21.55%, N = 123, n = 25) reported to hunt wildlife at least twice a week, followed by once a week (18.97%, N=123, n =22), twice a month (17.24%, N = 123, n =20), and once a month (12.07%, N = 123, n = 14, Fig. 3.2).
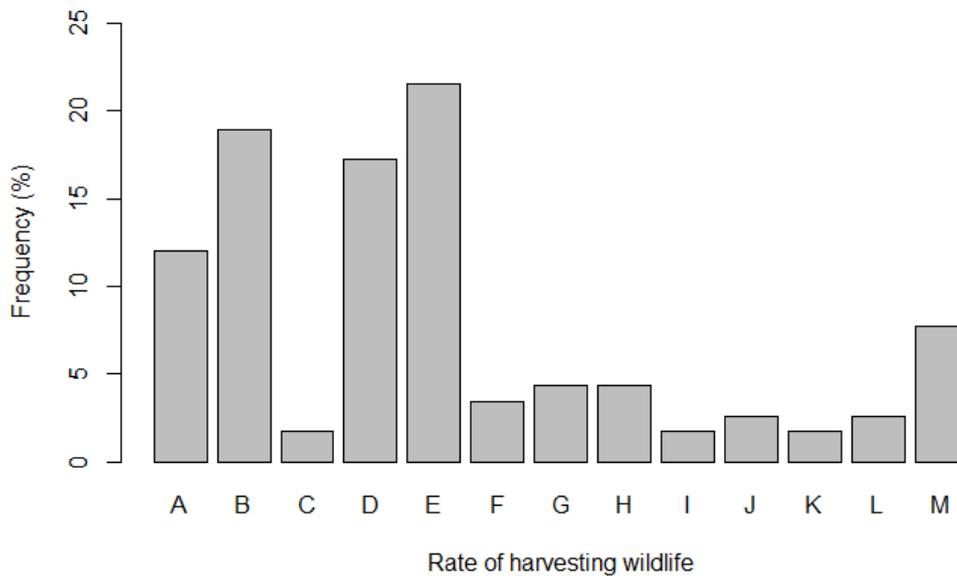
Figure 3.2: Relationship between annual hunting rate and number of people involved per hunting

Figure 3.2: Rate (frequency) of hunting wildlife in the study area. Letter A to M are frequency code. Expression of those letters are as follows: A = once per month, B = once per week, C = once per year, D = twice per month, E = twice per week, F = twice per year, G = thrice per month, H = thrice per week, I = thrice per year, J = four times per month,   K = four times a year, L = five times per year, and M = "None".

The number of people involved in illegal hunting range from 1 to 60 at once. There was significant difference in number of people who hunt wildlife in the area (Wilcoxon, V = 7381, P < 0.01). Also, the difference on number of people involved in hunting wildlife among ethnic groups interviewed was assessed. The result indicated the insignificant difference in number of people involved in hunting between tribes (Kruskal Wallis,   KW Chi-squared = 8.1092, DF = 12, P = 0.7765). Frequent hunting of wildlife may indicate high level of illegal wildlife trade.

3.3.3 Temporal variation of hunting rate of wildlife by hunters

There was significant difference of hunting rates over time categories (whether hunting preferred in the night, during the day, or both, GLM, Deviance = 12.352, DF = 120, P = 0.002).
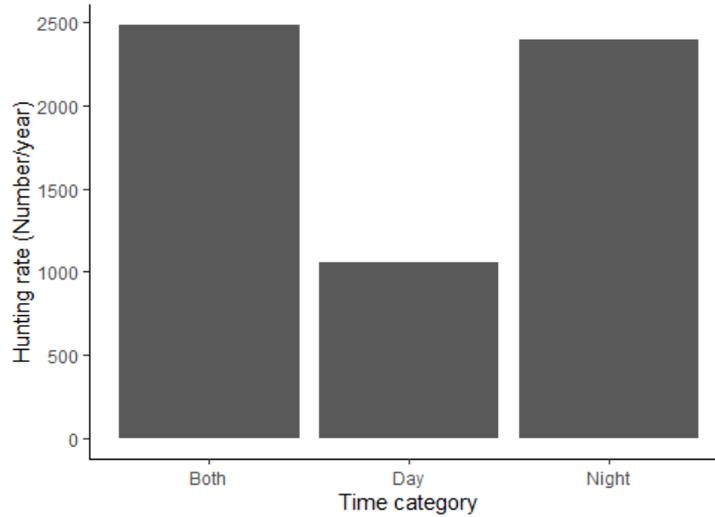
Figure 3: **Relationship between annual hunting rate with the time of the day preferred by hunters**

The posthoc test revealed that there was significant higher rate of hunting wildlife at night time ($P<0.0001$), and during the combined day and night time ($P = 0.004$, Table 3.1, Fig.3.3). Protection of wildlife is required especially during the night time.

Table 3.1: GLM with Poisson error distribution post-hoc results showing pairwise comparison of time preferred by hunters

Predictor	Estimate	SE	Z value	P value
Intercept	3.829	0.02	190.878	<0.0001
Time: Day time	0.045	0.04	1.226	0.2202
Time: Night time	0.101	0.03	3.515	0.0004

3.3.4 Drivers influencing temporal variation of hunting rates of wildlife

GLM with Poisson error distribution revealed that time of the day, occupation, ethnic group, religion, residence time, number of people available for hunting, presence or absence of moonlight, age, and education were the significant factors driving frequency or rate of wildlife hunting (Table 3.2).

Table 3.2: GLM Poisson mode results for driving factors influencing hunting rates of wildlife

Predictor	DF	Deviance	Residual	P value
Time	2	12.35	120	<0.01
Moonlight	2	121.59	95	<0.01
Occupation	5	61.63	115	<0.01
Tribe	14	266.95	101	<0.01
Religion	2	14.67	99	<0.01
Residence	1	163.20	98	<0.01
Number of people	1	389.12	97	<0.01
Age	1	27.45	94	<0.01
Education	3	136.58	91	<0.01

Hunter rate was higher during the night than during day time (Estimate = 4.236 ± 0.191 SE, Z = 22.242, P < 0.01). Hunting rate was significantly higher during the absence of the moonlight (Estimate = 3.824 ± 0.037SE, Z = 10.926, P < 0.01). Crop farmers associated to have higher hunting rate than other activity categories like business, livestock keeping, and employed people (Estimate = 4.767 ± 0.338, Z = 25.843, P <0.01). There was significant higher hunting rate associated with Hehe tribe than others (Estimate = 4.561 ± 0.292SE, Z = 25.442, P < 0.01).

Respondents with Christianity affiliation had significant higher hunting rate than Muslims and those without formal religion (Estimate = 4.236 ± 0.191 SE, Z = 22.242, P < 0.01). Hunting rate decreased with an increase of hunting experience, that implies hunters with few years of hunting experience associated to have higher hunting rate than experienced hunters (Estimate = -0.014 ± 0.002SE, Z = -9.464, P <0.01, Fig. 3.4).
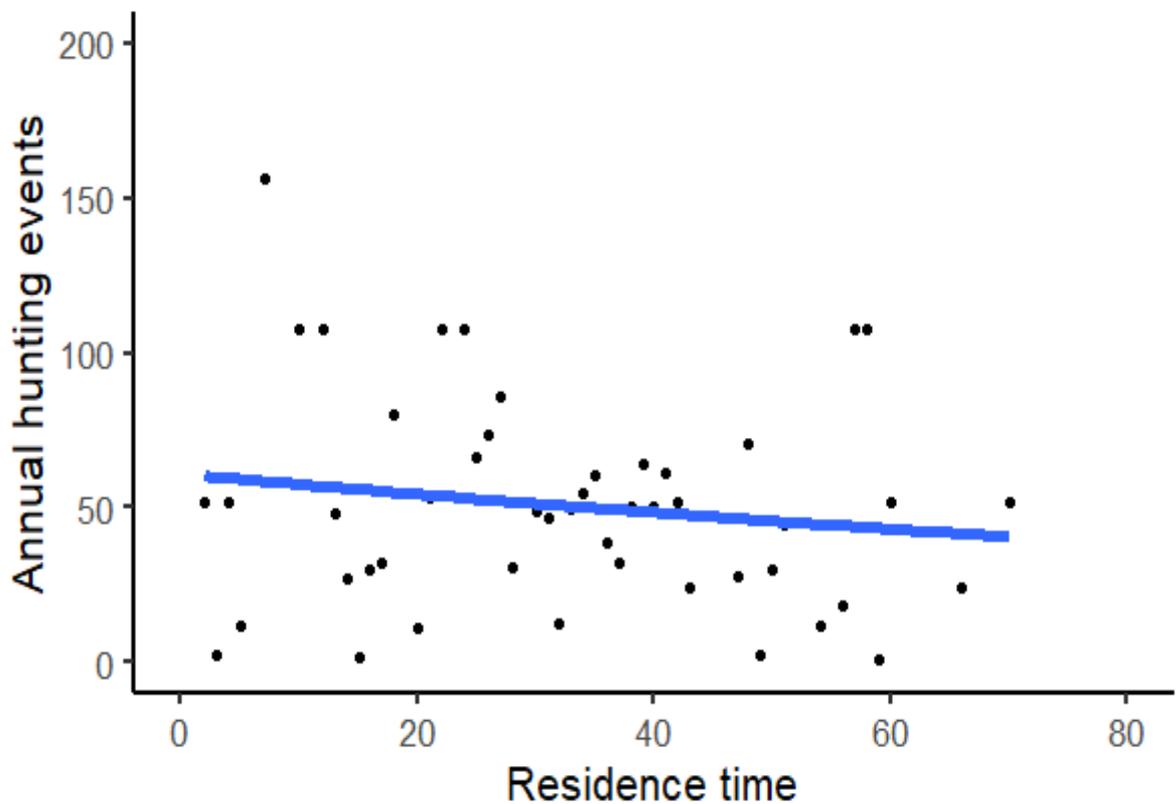
Figure 3.4: Relationship between annual hunting events and residence time (years) of the respondents

Hunting rates tend to decrease significantly with an increase of number of people involved per hunting. This may mean large number of people hunting or harvest many animals, but their frequency is low, compared to those who went for hunting with few people but their frequency is high (Estimate = -0.053 ± 0.003SE, Z = -15.776, P < 0.01). As experience of hunters, similar pattern was observed for age of hunters (Estimate = -0.007 ± 0.001SE, Z = -5.016, P < 0.01). Hunters with low level of education associated with the higher rate of hunting wildlife than literate hunters (Estimate = 4.3471 ± 0.2448SE, Z = 24.349, P = 0.034). Addressing illegal hunting of wildlife in this landscape require consideration of social factors underlined the problem.

3.3.5 Wildlife hunting trend

Trend of hunting wildlife over the past five years as reported by hunters decreased significantly (Estimate = -3.906 ± 0.013SE, Z = -292.71, P < 0.01). Increased protection of wildlife in both protected areas and in the village lands reported as the main reason of the decreased trend of wildlife hunting, however, when subjected to the GLM with binomial error distribution, all factors reported were not significant (Estimate = 0.6709 ± 0.532SE, Z=1.26, P = 0.208). Factors perceived by hunters as the main cause of the decreased hunting were increased awareness, increased conservation incentives, increased protection of wildlife, and decreased wildlife population size. Increased law enforcement produced promising results on the declined trend of hunting rate of wildlife.

3.4 Discussion

The temporal variation of illegal hunting in the Ruaha landscape revealed that the majority of the hunters reported hunting twice a week, and most hunting activities took place during the night. To make this study more robust, the study also included age, education, tribe, religion, and occupation to see if they could be driving factors in temporal illegal hunting. The results showed that all factors were significant factors that

contributed to illegal hunting in the Ruaha landscape. Furthermore, increased wildlife protection, raised awareness, and incentives were suggested by a majority as the main reasons for the decrease in illegal hunting in the past 5 years in the Ruaha landscape.

A majority of the respondents admitted that they enter the protected areas twice per week. This could be due to the fact that the majority of people living near protected areas depend on obtaining products such as bushmeat, firewood, honey, poles for building and fish, which are important components in their daily livelihood (Roe, 2002; Jones *et al.*, 2019). Also, findings could mean that there is a poor level of protection and the resources are very near to their settlement and could be linked to inexpensive accessibility (Lindsey *et al.*, 2011; van Velden *et al.*, 2020). These findings are consistent with other findings conducted in many places in Africa (Mgawe *et al.,* 2012; Ceppi and Nielsen, 2014; Knapp *et al.*, 2017; Jones *et al.*, 2019). The demand for wildlife products to meet important aspects of livelihood such as food, medicine, money, and other cultural matters influences the rate of illegal hunting in the Ruaha landscape and in other places of similar characteristics.

The pattern of illegal hunting of wildlife species in the Ruaha landscape was shaped by the variation of time. The analysis of temporal variation revealed that most hunting activities were conducted during the night. Night was suggested as a suitable hunting time due to less patrol by rangers and easy to catch wildlife species. In addition, respondents claimed that the absence of moonlight added catchability of wildlife species since they hunt using torches. When the animal is lighted by the light from the torch, it will stop and will be speared or attacked by dogs. This finding is contrary to the finding of Lindsey *et al.* (2013), who suggested that moonlight is preferred by the hunters during illegal hunting because it helps to locate the animals and makes it easier to detect dangers. In other cases,

the research found that people spent the night on their farms to protect crops from crop-damaging animals like bush pigs, warthogs, eland, and kudus; the majority claimed that they used this time of the night to hunt wildlife species. Studies in the Serengeti National Park, and elsewhere observed a similar scenario to what was found in this study (Loibooki *et al.*, 2002; Holmern *et al.*, 2007; Angela *et al.*, 2012). More information from the respondents suggested that most of the illegal trade of wildlife products is conducted during the night, as observed in the Kilombero valley, in order to escape detection from police and anti-poaching patrols (Nielsen *et al.*, 2016). This analysis implies that a large number of wildlife species are hunted during the night and therefore contributes largely to the decline of wildlife populations.

The analysis of the drivers of temporal illegal hunting revealed that time of the day, occupation, ethnic group, religion, residence time, number of people, moonlight, age, and education influence illegal hunting of the wildlife species in the Ruaha landscape. As it been reported, most of the illegal hunting and trade were conducted during the night, and a similar case was also reported by (Mfunda and Røskaft, 2011; Nielsen *et al.*, 2016). Also, the occupation was reported to influence illegal hunting. This is due to the fact that lack of capital and unemployment influence the majority of the people to engage in illegal hunting. This finding is similar to other studies that suggested that unemployment and lack of capital could influence illegal hunting (Roe, 2002; Samwel, 2017). Ethnicity was also analyzed and revealed that the Hehe tribe was more involved in illegal hunting for bushmeat than others. This is, however, related to their residence time and nature of activities; the majority of them are farmers (Dickman, 2008; Mrosso *et al.*, 2022), and this is consistent with other studies conducted in southern Tanzania (Mgawe *et al.*, 2012; Ceppi and Nielsen, 2014).

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Furthermore, the results show that Christians were more involved in illegal hunting than other religions. This could be due to the nature and beliefs of Christians that are not selective in eating animal species. Corresponding studies show some animals like bush pigs and warthogs are not used by Muslims due to their beliefs (Bachmann *et al.*, 2019). In most cases, similar results to others that lack education and the number of people in the households were cited as factors influencing illegal hunting (Mgawe *et al.*, 2012; Ceppi and Nielsen, 2014; Mrosso *et al.*, 2022). Large family size means more opportunities and resource requirements are needed to sustain the family. Hence, when the only resource available is wildlife, people will expect illegal hunting to dominate in their areas (Jambiya *et al.*, 2007; Angela *et al.*, 2012; van Velden *et al.*, 2020). In this case, the analysis of social factors presents a small amount of evidence of the reliance of people toward wildlife resources such as wild meat, and the experience from other regions is also in line with these findings. Furthermore, this study found that the trend of illegal hunting in the Ruaha landscape has decreased for the past five years. Increased wildlife protection, conservation awareness, decreased wildlife and conservation incentives were suggested as the main reasons for the decline in illegal hunting. These results corresponded with other studies that suggested increased protection by well-funded anti-poaching units could reduce illegal hunting (Vicenti and Chansa, 2012; Bachmann *et al.*, 2019). However, Barnett (2000) and Lindsey *et al*. (2013) added that conservation incentives combined with conservation awareness could yield promising results also, as Baldus and Cauldwell (2004). It has been suggested that in order to manage sustainable conservation, there must be integrated efforts between conservation and the wellbeing of people, especially those living near protected areas (Jambiya *et al.*, 2007; Picard, 2015).

Furthermore, this study found that the trend of illegal hunting in the Ruaha landscape has decreased for the past five years. Increased wildlife protection, conservation awareness,

decreased wildlife and conservation incentives were suggested as the main reasons for the decline in illegal hunting. These results correspond with other studies that suggested increased protection by well-funded anti-poaching units could reduce illegal hunting (Vicenti and Chansa, 2012; Bachmann *et al*., 2019). However, Barnett (2000); Lindsey *et al*. (2013); Baldus and Cauldwell, (2004) added that conservation incentives combined with conservation awareness could yield promising results. It has been suggested that in order to manage sustainable conservation, there must be integrated efforts between conservation and the wellbeing of people, especially those living near protected areas (Jambiya *et al*., 2007; Picard, 2015).

3.5 Conclusion

The temporal variation of illegal hunting in the Ruaha landscape revealed a wide range of illegal hunting by time, season, socio-demographic, and trends. The analysis of these variables portrays that these factors influence illegal hunting, and the long-term dependence of wildlife products for livelihood of the majority of people who live near protected areas. The rate of hunting is very high, which implies threats to wildlife conservation; also provides a sign that the majority do not have alternative livelihoods to meet their daily needs. Illegal hunting and trade during the night presents another challenge in conservation. The huge risks taken by people in order to obtain wildlife products to feed their families and sometimes cultural aspects is another concern to note. As a result, developing alternative sources of food and income generation is unavoidable in order to reduce local communities' reliance on wildlife resources. The decreasing trend of illegal hunting for the past five years provides the fact that governments (political will), private organizations, and projects should invest more effort in three important areas as suggested by the respondents. These areas include protection, which means improving

protection units and building capacities for rangers and police in order to increase efficiency in curbing or fighting illegal hunting and trade of wildlife products.

3.6 Recommendation

The government, private organizations, and projects should take the required action to save people and their wildlife from illegal hunting. Improving and increasing protection of wildlife species should be well-matched with these communities' strategies of hunting during the nights. Consideration of sociodemographic factors in addressing conservation challenges is crucial as it is noted that these factors have effects on the conservation of wildlife species.

Future studies should take into account these factors as they have a powerful link with illegal hunting and could have an impact on other studies that are linked to conservation. Conservation awareness should go hand in hand with the provisions of conservation incentives. People need more awareness of the benefits and cost of conservation in their lives. However, incentives should include direct and indirect benefits from the conservation of wildlife resources.

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CHAPTER FOUR

Third Manuscript

4.0 Illegal Wildlife Trade: Trade Flows of Wildlife Products and Facilitation Methods in the Ruaha Landscape, Tanzania

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CHAPTER FIVE

5.0. GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 General discussion

This study found that impala, dik-dik, kudu, lions, elephants, warthog, giraffe, and buffalo were the most hunted wildlife species in the Ruaha landscape. However, along with these most hunted wildlife species, the analysis shows that most wildlife products harvested and used are obtained from these wildlife species. This means that there is a strong association among the most hunted wildlife species and their products (Angela *et al.*, 2012; Coal *et al.*, 2020). According to a related study conducted in the Ugalla Game Reserve, most poachers arrested for illegal hunting were hunting not only for bushmeat but also for other wildlife products such as skin, fats, ivory, claws, horns, and scales (Wilfred, 2020). This suggests that there are extensive uses of wildlife products in the Ruaha landscape as the study shows most wildlife products are used for food, income, medicine, traditional trophies, and spiritual purposes (Knapp *et al.*, 2017; Coal *et al.,* 2020).

In this case, food and income contributed to more than 60% of the use of wildlife products in the Ruaha landscape. This suggests that more people engage in illegal hunting for the purpose of securing food (protein supplements) and as an activity that helps them generate additional income (Angela *et al.,* 2012; Knapp *et al.,* 2017; Afriyie *et al.*, 2021). In addition, the results show that illegal hunters used dogs, snares, spears, and torches to hunt these wildlife species in the Ruaha landscape. These findings suggest that cheap and easy methods like dogs, snares, and spears are used in illegal hunting, and ethnic variation in illegal hunting was also observed throughout this study (Knapp *et al.*, 2017; Coal *et al.,* 2020). In the Serengeti National Park, Tanzania and elsewhere in Africa, snares and guns are widely used (Loibooki *et al.,* 2002; Lindsey *et al.,* 2013; Samwel, 2017; Rija, 2022).

In this study, dogs were commonly used, followed by snares, spears, and torches. This implied that there could be geographical and preference variations in illegal hunting methods.

The temporal variation of illegal hunting in the Ruaha landscape shows that the majority hunt twice per week in the Ruaha National Park and MBOMIPA Wildlife Management Area. This could suggest a high level of dependence on wildlife products for their livelihood (Barnett, 2000; Ceppi and Nielsen, 2014; Samwel, 2017; Afriyie *et al.,* 2021) and may imply that these resources are found close to the villages and the protection level is poor, which influences the frequency of entering into the protected areas for illegal hunting (Jambiya *et al.,* 2007; Mgawe *et al.,* 2012). Most hunting activities are conducted during the night in the absence of moonlight. The main reasons given were: poor protection at this time of the day, easy to catch wildlife species, especially when they are using dogs and torches. This finding corresponded with the Kilombero and Serengeti studies, which explained the illegal hunting and trade of wildlife products during the nights (Mfunda and Røskaft, 2011; Nielsen *et al.,* 2016).

Further examination of age, education, religions, resident time, family size, and ethnicity revealed that these factors have a significant impact on the temporal variation of illegal hunting in the Ruaha landscape. These findings corresponded with other studies which identified each of these variables and their influence on illegal hunting for bushmeat (Mgawe *et al.,* 2012; Ceppi and Nielsen, 2014; Bachmann *et al.,* 2019; Jones *et al.,* 2019). In addition, analysis shows that the trend of illegal hunting has decreased for the past five years, the majority suggested protection, and provisions of conservation awareness and incentives help to reduce illegal hunting in the Ruaha landscape. It was recommended that well-funded anti-poaching patrols and provision of alternative livelihoods would produce

promising results in the conservation of wildlife species (Lindsey *et al.,* 2013; van Velden *et al.,* 2020; Rija *et al.,* 2020).

The trade flow of wildlife products revealed that most of the wildlife products originate from Ruaha National Park and MBOMIPA Wildlife Management Area. This could be due to the close distance between the protected areas and the villages (Ceppi and Nielsen, 2014; Kidegesho, 2016; Afriyie *et al.,* 2021). Readings suggested that communities living near wildlife resources were more likely to engage in illegal wildlife resource collection than those living far away (Jambiya et al., 2007; Mgawe *et al.,* 2012; Jones *et al.,* 2019). Furthermore, the study found that more than 30% of wildlife products originated from the village land. These village lands are the areas within the village that have a high number of wildlife species and less protection compared to other protected areas (Kidegesho, 2016; Bachmann *et al.,* 2019). The transportation of wildlife products in the Ruaha landscape was dominated by local transport systems like walking on foot and using bicycles to transport wildlife products from one village to another.

This implies that the nature of people involved in illegal hunting is poor people who mainly hunt wildlife products for subsistence (Lindsey *et al.,* 2013; Nielsen *et al.,* 2016). Most wildlife products were transported within the village and near villages, and as it was observed in the Kilombero, most of the trade was conducted during the night and the main transport was bicycles (Nielsen *et al.,* 2016). As in most studies, the findings of this study revealed a similar pattern: there is a long-term relationship between hunters, traders, and consumers of wildlife products (Vira *et al.,* 2014; Nielsen *et al.,* 2016; Jones *et al.,* 2019). This kind of relationship is very secretive and encourages others to join in the business of illegal hunting and trade of wildlife products, as reported by the majority of respondents. In other cases, the study found that wildlife products could be exchanged

with other materials like maize and rice. This could be due to the fact that many hunters do not have good arable land for farming, so they depend on illegal hunting to obtain their livelihood requirements.

5.2   General conclusion

This study explored the trade flow of wildlife products in 16 villages surrounding the Ruaha landscape, Tanzania. The findings from this study indicated the extensive illegal hunting of wildlife species, including impala, kudu, dik-dik, zebra, giraffe, lion, and elephant. Most of these hunted species are hunted by using dogs, snares, spear and torch. The main wildlife products collected were meat, skin, claws, horns, tail, fat, ivory and excretes and were used for food, income, medicines, traditional trophies and spiritual purposes. However, ethnic variation of using wildlife products observed in the Ruaha landscape, where by most lion and pangolin products were commonly used by pastoralist such as Barabaing, Maasai and Sukuma, while wild meat was highly used by the other tribe like Hehe, Gogo, Sagara, and Sangu.

Also, the temporal variation of illegal hunting in the Ruaha landscape suggested that people went for hunting wildlife twice a week, and most hunting is conducted during the night in the absence of moonlight in order to avoid being detected by patrol rangers. Sociological variables such as age, tribes, education, resident time, religions, family size found to influence illegal hunting. However, increased wildlife protection combined with increased conservation awareness and incentives were suggested as reason for the decreased illegal hunting in the Ruaha landscape for the past five years.

On the illegal trade flow of wildlife products, the findings show the stunning results with complex networks of trade and flow of wildlife products from one village to another,

within Ruaha landscape and outside the landscape. Ruaha National Park and MBOMIPA Wildlife Management Area were acting as the main source of wildlife products, including village land where 30% of the products originated. Wild meat was the main products traded in the Ruaha landscape. In such case, the study observed the strong relationship among hunters or poachers and their customers like traders, and consumers, most of them were friends, neighbours and relatives. Several products like maize, rice and in some cases livestock were used instead of cash to exchange with wildlife products. In order to transport wildlife products from one place to another different method were mentioned by respondents such as via feet, bicycles, motorcycles and vehicles. Moreover, respondents admitted to be influenced by their friends, relatives and sometimes their parents to engage in the illegal hunting and trade of wildlife products. This indicated that the link and network of illegal trade in the Ruaha landscape is complex since it involves many actors and it is conducted in extremely secrets which is the reasons of existing trade flow of wildlife products within their villages, neighbour villages and in some cases it was reported the product reach Iringa town, Mafinga, Madibira which is far distance from the source of the products.

5.3 General recommendations

The rate of declining population of medium and small-sized mammals is very high due to intensive poaching in the Ruaha landscape. Therefore, the government and other responsible stakeholders should prepare strategies and action plan for combating illegal hunting of these species.

Management authorities and conservation specialist to monitor wildlife species the best time to be considered for minimizing illegal hunting is night time. However, the socioeconomic elements are critical to consider when addressing the illicit hunting of

wildlife species in the Ruaha landscape. In addition, increased law enforcement produced promising results on the declined trend of hunting rate of wildlife in the Ruaha landscape. Similarly, improving agricultural practices could help to reduce dependence of local communities on the available wildlife resources.

The wildlife policy should improve game meat selling regulation and legalizing bushmeat sell. This could help to reduce the dependence of communities in illegal hunting to obtain protein supplements.

Furthermore, further research should be done to understand the population size of the medium and small sized mammals in the village land where most of the illegal hunting often conducted.

Therefore, knowledge on forensic sciences is needed to help in the detection of wildlife products transported, more research is needed to examine the impact of illegal wildlife trade and spread of diseases and pathogens. In addition, a well-funded anti-poaching will help to reduce the illegal hunting and trade of wildlife products.

Lastly, the government should improve the policy of accessing wildlife products data and other important information needed for the research purposes. Currently it is difficult to access information like trophies or other wildlife products in government institutions, long procedures and delay contributed to lack of legal data for wildlife products in some WMAs like MBOMIPA.

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APPENDICES

Appendix 1: Questions for household

A. Demographic Information

Respondent code	
Gender	
Age	
Village name	
Tribe name	
Occupation	
Education level	
GPS Coordinates	

B. Identification and Uses of Wildlife Products (Specific Objective 1)

1. What are the wildlife products available in this area?

2. What are the uses of wildlife products available in the study area?

3. How do you obtain wildlife products?

    Bought…, harvest………. other way explains……

4. How often do you get wildlife products?

    (a) Everyday……………………...

    (b) Per week…………………………

    (c) Per month……………………………

    (d) Per year……………………………….

5. Where are the products coming from?

6. Which seasons you mostly go for hunting? 1. All 2. Dry 3. Wet 4. Between Wet and Dry

7. Who are the target customers and or traders for the wildlife trade?

8. Do you consider age and sex of the animal when you go for hunting?..................
    please explain why,

9. Which animal sex and age is suitable for hunting………

10. How long it takes for the customers to get the products……

11. How are the wildlife products transported from the source to the end market?

12. who is paying you for harvesting or hunting wildlife?...............................

13. Where is the centre or market for wildlife product in the village?...................

14. Which ways or routes did you use to transport wildlife products to the market…...

15. List wildlife products mostly demanded by customers? ----------------

Explain why? ----------------------------------

16. Where do you often harvest /obtain wildlife products?

   a) Village land

   b) Wildlife management area

   c) Game reserve

   d) Ruaha national park

17. Others, explain…………………

18. When you go for hunting how many species do you harvest? ……

Per day…. per week… per month…..., per month, per trade………. (if they set several traps)

19. Apart from going to hunt in the protected area, where else do you obtain wildlife product?

   a) Buy from the markets

   b) Buy from others

   c) Exchange with other goods

   d) Obtained from friends/partners

B. Determine the origin, rate and quantity of wildlife products involved in the trade flow (specific objective 2 and 3)

16**.** Where is your customers for wildlife products located?

    a) Within the village

    b) Other village

    c) Near township; and names

    d) Farthest township; and names

    e) Neighbour country; and names

    f) Others, specify…………………

20. What has been the trend of wildlife trade for the last 10 years, and why?

    a) Increased

    b) Decreased

    c) Remain the same

       Why? …………………

20. What has been the trend of wildlife trade before and after 2016? And why?

    a. Increased

    b. Decreased

    c. Remain the same

   Why? ………

21 Is there anyone from other country doing trade with you? YES/ NO, If Yes which country……………

22. In general, is harvesting the wildlife products a planned activities or opportunistic? …………

23. When you go for harvesting of wildlife species, do you hunt

    a) Any wildlife species, if yes which species have you harvested?..............

    b) Specific targeted species, if yes what are most target species for you……

24. At what time is suitable for harvesting wildlife species?

      a) During the day

      b) During the night

      c) Absence of moonlight

      d) Presence of moonlight

25. Which equipment you normally carry during hunting?.........................

26. Mention the use of each equipment…………………........

27. How many people you often go for hunting per hunt? And Why?...............

28. How did you find your hunting or trade partner?....................................

29. What is your relationship with your hunting or trade partner?......................

30. Why did you choose or accept him/her as your hunt or trade partner?..............

31. What are challenges you face in your relationship with partners?..............

32. How do you communicate with other member in the trade chain?...................

33. How do you reach/find your customers……………?

34. Is there any routes used during trading the wildlife products in the village, town and others?..................................

C. Key Informant Interview Form

1. Name of respondent……………………

2. Position/occupation……......

3. Location …………………………………

4. GPS coordinates……………………………………

5. Which types of wildlife products are often involved in the trade?.....................

6. What are the products used for?

7. Where is the source of wildlife products? ……………

8. Location/place where seizure take place……………………

9. Reasons for seizures…………………………

10. What were the means of transport.........................

11. The nationality of the offender/trader……………………

12. Where the wildlife products intended to go/ destination? …….

a) Domestic trade………………………………

b) Regional trade………………………………

c) International trade…………………………………

13. What amount or size of each the product transported for the past 5 years? ………

14. What means used by traders to transport wildlife product? …………

15. How often do you obtain/ seizure/ caught wildlife products?

a) Everyday   b) Per week   c) Per month   d) Per year

16. How do the illegal traders of wildlife product escape the patrol unit? …………

17. Is there relationship between illegal and legal traders of wildlife products? (Yes/No),

explain……

18. What are the challenges facing when you caught the wildlife trader dealers?.........

Appendix 2: List of wildlife products involved in the trade flow

Species	Products																						
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Lion	9	34		42			1		22	42		3	6									6	
Elephant	33	5			44	14	7	2	4	2			4				7	5	4				
Impala	101	5	10				11																
Kudu	83	3	15									1											
Buffalo	47	17	9						4			1	1										
Dik-dik	63		6																				
Giraffe	43	4						4	7	4											2		
Warthog	37								8		1			6									
Eland	32	7	7							2		1											1
Zebra	43	4										1											
Guinea Fowl	21																				8		
Leopard	2	10		5					2	3		1											
Bush pig	14									4													
Bush buck	15																						
Porcupine	9														2								
Hare	11																						
Hyeana	2	4							2														
Hippo	3	1										2				2							
Pangolin	2			2											2	2							
Baboon	3	1							1														
Monkey	1																				1		
Cheetah		1		1																			
Crocodile		2																					
Sable Antelope	1																						
Mongoose	1																						
Wild dog		1																					
Total	576	99	47	50	44	14	19	6	50	53	5	10	11	8	4	3	7	5	4	2	8	6	1

Table 2: Wildlife products from all reported species. Total product represent summation of all reported products per species. Letters A to X represent codes for product types that involved in the trade flows. Expression of product code are as follows; A= Meat, B = Skin, C = Horn, D = Claws, E = Ivory, F = Dung, G = Testicles, H = Liver, I = Tail, J = Fat, K = Nose, L = Bone, M =Throat, N = Teeth, O = Spine, P = Whole body, Q = Placenta, R = Trunk, S = Ear, T = Leg, U = Feathers, V = Paw, W = Eyes, X = Intestine

Appendix 3: Most hunted wildlife species in the Ruaha landscape

Species	Scientific name	Frequency	Percent
Impala	*Aepyceros melampus*	101	82.11
Greater Kudu	*Strepsiceros strepsiceros*	83	67.48
Dik-dik	*Madoqua kirkii*	62	51.22
Buffalo	*Syncerus caffer*	48	39.22
Zebra	*Equus quagga*	45	36.59
Elephant	*Loxodonta africana*	45	36.59
Lion	*Panthera leo*	45	36.59
Giraffe	*Giraffa camelopardalis*	42	34.15
Warthog	*Phacochoerus africanus*	36	30.05
Eland	*Turotragus oryx*	31	25.20
Guinea fowl	*Numida meleagris*	21	17.70
Bush buck	*Tragelaphus scriptus*	15	12.20
Bush pig	*Potamochoerus porcus*	14	11.38
Leopard	*Panthera pardus*	14	11.38
Hare	*Lepus microtis*	11	8.94
Porcupine	*Hystrix galeata*	9	7.32
Hyaena	*Crocuta crocuta*	5	4.07
Pangolin	*Smutsia temminckii*	4	3.25
Baboon	*Papio cynocephalus*	3	2.44
Hippoportamus	*Hippopotamus amphibious*	3	2.44
Nile Crocodile	*Crocodylus niloticus*	2	1.63
Cheetah	*Hippotragus niger*	1	0.81
Wild dog	*Lycaon pictus*	1	0.81
Sable antelope	*Hippotragus niger*	1	0.81
Mangoose	*Mungos mungo*	1	0.81
Vervet monkey	*Chlorocebus pygerythrus*	1	0.81

Appendix 4: List of wildlife products and their uses

Product	Main uses of wildlife products	Total use
Meat	Subsistence , income, treatment, confidence, supremacy	5
Lion fat	Chasing crop damaging animals, heal neck, back bone pain, or dislocation treatment, protect against evil spirits, heal ear problem and paralysis.	7
Lion and leopard skin	Symbol of prestige, source of income, self-empowerment	3
Lion, buffalo, elephant bones	Wear in the body to protection against evil spirits and demon, to protect farms	2
Lion teeth	Heal the swelling of the neck (goitre) and teeth	2
Lion forehead skin	Guard against evil spirit, symbol of esteem and brevity, income	3
Lion. Leopard, and Spotted Hyaena claws	Cure convulsions in children, symbol of brevity, heal bad luck, and income	4
Lion paw	Symbol of prestige and protection	2
Lion tail	Chase away evils spirits, symbol of brevity and kept as trophy.	3
Lion and buffalo throat	Increase confidence, cure chest pain, whooping cough	3
Lion, baboon, impala, testicles	Increase fertility and potency for men	2
Impala horn	Storage of traditional medicine, alarming, decoration	3
Eland horn	To protect against evil situation, increase number of cattle	2
Eland fat	Infertility to women, used to protect in the bush, escape danger	3
Warthog and baboon tail	Increase erection and potency for men	2
Bushpig, warthog nose	Protect family and farms against evil spirits and bad omen	2
Giraffe leg	Cure boils, increased attraction in the life and in business	3
Giraffe fat	Cure swelling in body, cure ear problems, add attraction	3
Giraffe liver	To cure liver problems in human body	1
Elephant ivory	Business, good luck, trophy, increase livestock	4
Elephant liver	Cure human liver diseases, cure premature children	2
Elephant ear	Cure leprosy, swelling, and sign of brevity and pristine	4
Elephant tail hair	Make hand rings, decorations, prevent farms against evils	3
Elephant trunk	Increasing body strength, giant and masculine	3
Elephant dung	Cure for convulsions in children and fever	2
Elephant fat	Cure abnormal weights in children, magical power	2
Elephant placenta	Easy delivery without operation and cure female infertility	2
Pangolin	Sign of good luck, or bad lack, rituals, income	4
Pangolin scale	Chase evil spirits, increasing livestock, chase lions cure chest, neck, stomach, nose bleeding, bring luck, affairs, business, also income	12
Dik-dik horn	Making medicine used to treat livestock foot diseases	1
Buffalo skin	Rope for tying donkey, clothes, traditional symbol, income	4
Buffalo horn	Protect house from shamans, and for decoration.	2
Buffalo tail	Chase evil spirits away and in ritual purposes	2
Porcupine intestine	Cure human stomach pain	1
Porcupine spine	Cure bleeding, abdominal pain, pneumonia, shamans tools	4
Porcupine excretes	Heal and cure human teeth and prevent them from decaying	2
Baboon skin	For comedy shows and ceremonies, made drums	3