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Where leaders learn

Bushmeat hunting and use by rural communities living adjacent to indigenous forests in the Eastern Cape province, South Africa

A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

by

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October 2024

ABSTRACT

The use of forest wild species directly contributes to the well-being of billions of people globally and is particularly important to people living in vulnerable situations. Rural, indigenous communities have harvested a variety of timber and non-timber forest products (NTFPs) for millennia and still do to date. For these people, forests provide many products and benefits such as food, medicine, fuelwood and a source of income from trade in these items. In South Africa, a large number of studies have investigated the harvesting and use of NTFPs, highlighting their importance to rural and urban communities. Additionaly, the hunting of wild mammals occurs throughout the Afro-temperate forests of South Africa. Yet, no comprehensive study has been conducted on the hunting and use of wild forest mammals in the region. I sought to investigate the motivations, extent and impact of local hunting in the indigenous forests of the Eastern Cape. I hypothesize that in the region hunting is not a primary source of nutrition or income, but it continues to hold cultural significance, reflecting deep-rooted traditions within these communities. Understanding bushmeat hunting and use in the region is key to guiding sustainable management and assessing the need for policy adjustments.

The current study firstly provides a detailed evaluation of NTFPs harvesting and use, highlighting the livelihood benefits associated with bushmeat hunting by investigating bushmeat hunting patterns and consumption by rural communities surrounding forest patches in the Eastern Cape province, South Africa. Here bushmeat hunting refers to the informal hunting of wild mammals by rural communities, primarily for subsistence consumption. While often organised and small-scale, it is shaped by local ecological knowledge, cultural traditions, and resource availability. The practice occurs within a complex illegal and socio-economic landscape, where access to alternative protein sources, conservation regulations, and historical land-use patterns influence its prevalence and significance. To assess NTFP harvesting and bushmeat hunting, 12 villages at different proximities to forests were selected around the province. Using a quantitative approach in the form of guided, semi-structured interviews, data on the extraction and use of NTFPs, bushmeat hunting, frequency of bushmeat consumption, general protein consumption and food security of each household were solicited. Only 16% of the households attested to hunting in the 12 months prior to the survey, with all these households including an active hunter. Though 64% of the interviewed head of households mentioned that they had consumed bushmeat in the past year, these were mostly men, only 12% percent mentioned that the hunter in the household brought their catch home and consumed the meat with their families. Hunters mostly consumed their catch with other

hunters, non-hunting males and young boys. Hence the study concluded that bushmeat consumption was not an important livelihood strategy nor food source of rural people but instead plays a significant social and cultural role in the region.

I also provide comprehensive insights into bushmeat hunting practices in the province. Though conducting in-depth questionnaire surveys with self-identifying hunters from the 12 villages I was able to determine the motivations, methods and perceptions behind bushmeat hunting. A total of 147 hunter interviews were conducted. All the interviewees were male, with a mean age of 32 ± 9 years. The primary motivations behind bushmeat hunting were culture (40%), sport/competition (33%) and recreational purposes (20%). Contrary to hunting in the tropics, only 4% mentioned that they hunt for income. Most of the hunters (44%) used mixed hunting methods. This involved setting up or checking snares whilst hunting with dogs and sticks, 27% only used dogs and sticks and 17% only used snares. Hunters reported ten mammal species caught in forests of the Eastern Cape in the last 12 months. Bushbuck (*Tragelaphus scriptus*), Common duiker (*Sylvicapra grimmia*) and Cape porcupine (*Hystrix africaeaustralis*) were the most hunted species. All the hunters acknowledged that hunting was an illegal activity and if caught they could be arrested.

The study further presents a thorough assessment of forest mammal species diversity under hunting pressure. Evidence suggests that higher hunting occurs in communal land forests compared to forests on protected or privately owned land. Hence, data on species richness and abundance within fenced protected forests and neighbouring unfenced communal forests was acquired using a mixed-methods approach in the form of ecological line transects and local ecological knowledge (LEK) surveys. The line transects revealed a mean mammal species richness of 7.6 ±1.3 in the protected forests, 5.3 ±1.4 in the Afromontane communal forests and 3.3 ±1.6 in the Coastal communal forests. The Afromontane and Coastal communal forests had a mean species abundance of 12.1 ± 5.4 and 6.5 ± 5.0, per forest respectively, whilst the protected forests had a mean species abundance of 18.0 ± 7.0. During the LEK surveys hunters from villages close to the forests reported more species (8.9 ±1.7) than those from far villages (7.3 ± 1.2). The regular forest users reported a mean species richness of 5.5 ± 1.2 and the local experts from the protected forests reporting a mean species richness of 13.4 ± 0.7. The study demonstrates the importance of mixed-methods approach in wildlife research and sustainable natural resource use. The current study clearly shows that protected areas support higher biodiversity and that local forest users' knowledge aligns well with ecological data.

Lastly, I present a social-ecological assessment of bushmeat hunting in the forests of the Eastern Cape. The use of traditional biological sustainability indices have proved inadequate for measuring the impact of bushmeat hunting because sustainability is treated as a static, binary question, thus ignoring stochastic processes, the inherent variability of natural systems, and the complexity of hunting systems. I hence used a combination of social and ecological methods to gain insights on how the offtake of forest mammal species affected species density in the communal forests of the Eastern Cape and also how this influenced hunting practices and behaviour. The density estimates of the hunted mammal fauna in the communal forests was significantly less (50%) than in the protected forests in the region. Also, the density estimates for the five most hunted mammal species in the communal forests were significantly lower (15%) than density estimates reported in the literature. Additionally, participatory hunter interviews revealed a decline in catch per unit effort and harvest rates over the past 10 years. This decline resulted in changes in the hunting strategies and patterns of many hunters. I argue that bushmeat hunting systems should be regarded as social-ecological systems in which the animal populations are not the only focus. Instead, understanding the complex and dynamic relationships between the hunting ground, its resources, the stakeholders, and the different exogenous drivers of change that affect these components yields a better interpretation of sustainability.

The current study contributes to the growing knowledge of bushmeat hunting and use in the country and also provides novel findings on the sustainability of bushmeat hunting in the forests of the Eastern Cape. Here I provide an all-inclusive appraisal of bushmeat hunting and use by rural communities living adjacent to biodiversity-rich indigenous forests. The study provides in-depth insights on household bushmeat use, hunting practices and motivations of hunters and the effect of hunting on mammalian forest fauna. Furthermore, the study provides a novel approach to determining the sustainability of bushmeat hunting by using mixed social and ecological methods. The study can be used as a model for other studies assessing bushmeat hunting elsewhere in the country.

Keywords: bushmeat, forests, hunting, local ecological knowledge, mixed-methods, non-timber forest products, natural resource use, sustainability

DECLARATION

I, Vusumzi Martins, student number G19M9776, hereby declare that the thesis for Doctor of Philosophy (Environmental Science) entitled "Bushmeat hunting and use by rural communities living adjacent forests in the Eastern Cape province, South Africa" is my own original work and that all other sources used or quoted have been fully acknowledged and referenced. This thesis has not previously been submitted for assessment or completion of any postgraduate qualification to any other university or for another qualification.

Signature:_____ Date:_____

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ACKNOWLEDGEMENTS

This was by far the most challenging yet fulfilling journey I have ever embarked on, and it would have never been possible without the support of my wife, children and supervisors. To God be the glory for granting me the perseverance and strength to complete this thesis and for the people who assisted me through this journey.

To the Distinguished Prof. Charlie Shackleton and Prof. Alta De Vos, I would like to thank you for the constant guidance and assistance throughout the years. I am proud to consider both of you as my role models and mentors in life. To Prof. Charlie Shackleton, your wisdom and knowledge were invaluable to the completion of this thesis, thank you for providing this exciting opportunity, funding and the intellectual freedom to carry out my PhD under your SARChI Chair in Interdisciplinary Science in Land and Natural Resource Use for Sustainable Livelihoods. This research was funded by the South African Research Chairs Initiative of the Department of Science and Innovation and the National Research Foundation of South Africa (grant no. 84379). Any opinion, finding, conclusion or recommendation expressed in this material is that of the authors and the NRF does not accept any liability in this regard.

I would like to also thank all the people from the respective villages in the Eastern Cape who participated in the surveys, this study would have never been possible without you, uyabulela uDzana. To Eastern Cape Parks and Tourism Agency thank you for allowing me to conducted research in the Coastal nature reserves. Also, to the kind and welcoming reserve managers and their staff in all the ECPTA managed nature reserves I thank you for your assistance with field work. I also would like to thank Mbasa Baartman, Pamella Zondani, Tandisizwe Gcinywa, Luthando Maqwentshu and Sikhulule Sothondoshe for assisting me with field work and questionnaires.

I would like to also send my heartfelt gratitude to Dr. Mfundo Bizani (The DJ) for assisting and guiding me with my statistical analysis; you have taught me a lot buddy. Thank you to all the people who have supported me in various ways throughout this journey, Ndiyabulela.

DEDICATIONS

I dedicate this thesis to my late father (Eric Martins) and mother (Nomvula Baartman); may your souls continue to rest easy. To my wife (Pamella Silindokuhle Martins) thank you for your patience and constant inspiration throughout this journey. Also, to my children, from now on I am Dr Daddy.

Chapter 1

Introduction

1.1 General introduction

The term bushmeat refers to any wild terrestrial mammal, amphibian, bird, or reptile collected for human consumption (Van Velden et al., 2018; Groom et al., 2023). The term, however, has come to be largely associated with people living in tropical forested regions of the world, where bushmeat is often a mainstay of the local diet, largely due to the lack of alternative sources of protein and culture (Stone and Stone, 2022). In many African countries, the harvesting of wild animals for protein has become the greatest direct threat to wildlife; largely due to a complex combination of burgeoning human populations, the commercialization of bushmeat harvests, urban demand, and increased access to forests (Kendon et al., 2022; Lindsey et al., 2022). Unregulated harvesting of bushmeat may result in population losses of sensitive species, leading to local extinction (Ripple, 2016; Van Velden et al., 2020). On the other hand, human food insecurity and poverty are global crises, especially in developing countries (Booth et al., 2021; Enns et al., 2023). The relationship between bushmeat hunting and food security in rural areas is complex, and in some settings, there can be conflict between local subsistence, cultural needs, and broader conservation requirements (Van Velden et al., 2018; Fraint et al., 2020; Van Vliet et al., 2022). Addressing this complex human-wildlife interaction requires the integration of both ecological and social insights to promote sustainable use of targeted species and the broader ecosystems in which bushmeat hunting occurs.

In many settings, the complexity and potential for conflict are exacerbated by multiple contextual factors, including habitat loss and land transformation, urban demand for bushmeat, improved hunting technologies, poverty, increasing human populations, and a scarcity of alternative protein sources (Van Gills et al., 2019; Deith, 2022). Unsustainable offtake is likely to affect not only the species being hunted but also the functions these species play in the wider community ecology, such as fruit and seed dispersal and roles in nutrient cycles through grazing, browsing, and defecation (Ripple et al., 2016; Shackleton et al., 2018; Willis et al., 2022). Studies from western and central Africa show that bushmeat species conservation is important for achieving system ecological sustainability (Friant et al., 2020; Gonedelé-Bi et al., 2022; Stone and Stone, 2022), yet bushmeat hunting is also vital for the well-being of many

communities, given its role in human nutrition, health, welfare, and culture (Nasi et al., 2011; Lee et al., 2020).

In the South African context, most rural households make use of one or more natural resources extracted from local systems for energy, shelter and construction, food, medicine, weaving fibers, and culture (Shackleton and Shackleton, 2004; Mugido and Shackleton, 2019; Maroyi, 2022). Yet knowledge of the extent of bushmeat hunting and its use remains limited. A systematic review by Van Velden et al. (2018) concluded that bushmeat use in the savannas of southern Africa has been "severely understudied". Although they identified South Africa as the region with the highest number of published studies on bushmeat hunting, they still regarded it as low and insufficient. This echoed Gray-Ross et al. (2010), who previously stated that the "extent and effects of bushmeat hunting" in South Africa have rarely been examined. Recently, more research has generated insights into the hunting and use of bushmeat in the country (e.g. Manqele et al., 2018; van Velden et al., 2018; Young et al., 2018; Nieman et al., 2019; Sosibo et al., 2022).

Studies on household-level natural resource use in South Africa generally provide information regarding the prevalence of bushmeat consumption, and a few provide some details regarding species and quantities (Shackleton et al., 2007; Kaschula and Shackleton, 2009). These studies indicate that generally 30%–60% of rural households attest to consuming bushmeat, with over 80 % in some settings (Shackleton et al., 2002; Twine et al., 2003; White, 2004; Kaschula and Shackleton, 2012). However, these figures are likely to be conservative because (i) some households are unlikely to affirm eating bushmeat because it is regarded as illegal (for larger species) and they could be fined, (ii) some regard bushmeat as a sign of poverty that they would not wish to share with an outside researcher, (iii) they hunt in neighbouring protected areas or private lands and do not wish to reveal that, or (iv) they hunt species for specific medicinal or cultural purposes that they are unwilling to reveal to outside researchers (Martins and Shackleton, 2019). Hence, more detailed work is required to provide more accurate insights in all facets of the bushmeat social-ecological system.

Although the literature search terms used by Van Velden et al. (2018) meant that some livelihood studies were not covered in their review, it is clear that the understanding of bushmeat use and hunting in South Africa is limited, even when spanning all biomes rather than just savannas. Priority has been given to researching both legal (trophy hunting) and illegal (poaching) bushmeat hunting within formal protected areas, with relatively little research on

bushmeat hunting in communal or traditional lands (Martins and Shackleton, 2019). Livelihood literature (e.g. Kaschula and Shackleton (2009) provided quantitative data indicating that bushmeat consumption is widespread in South Africa. Hence, there is an obvious need to try to better understand the social-ecological nature of bushmeat hunting in the communal forest systems of South Africa and what the effects of hunting might be on the distribution and population viability of hunted species relative to and perhaps in synergy with other possible pressures, such as land transformation. Alongside this, there is a need to understand the role of urban dwellers in either hunting practices or bushmeat demand because South Africa is a rapidly urbanizing country.

The present study sought to address whether hunting remains an important socio-economic activity among rural communities resinding adjacent to Afro-temperate forests. We hypothesize that while hunting is still practiced in these communities, it no longer serves as a primary source of nutrition or income but retains cultural significance within modern rural societies. Using the Socio-Ecological Systems framework, we examine bushmeat hunting in the Eastern Cape Province of South Africa to understand its contemporary role and broader implications for sustainability and conservation. The forest biome in the region is considered one of the most species-rich subtropical forests in the world (Trimble and Van Aarde, 2011; Mucina et al., 2022). Forests are also regarded as the most threatened biome in the country, largely due to their very small area, fragmented distribution, and deleterious anthropogenic activities (Ngcobo et al., 2022). Most forests in South Africa are found in the Eastern Cape province (Leaver and Cherry, 2020), which is also the province with the highest poverty rate in the county (Mdoda et al., 2022; Thibane et al., 2023). This results in considerable dependence on local forests for a wide range of natural resources, including firewood, medicinal plants, edible fruits, housing materials, and bushmeat (Ncube et al., 2016; Maroyi, 2022). The forests in the region serve as refuges for many mammal species, both for forest specialists, such as the blue duiker (*Philantomba monticola*) and samango monkey (*Cercopithecus albogularis*), and for non-specialists, such as common duiker (*Sylvicapra grimmia*), black-backed jackal (*Canis mesomelas*), baboon (*Papio ursinus*), and vervet monkey (*Cercopithecus aethiops*) (Ehlers-Smith, 2016; Sosibo et al., 2022). Many forest-dwelling mammals have experienced significant declines in population due to different anthropogenic practices, including bushmeat hunting (Ehlers-Smith, 2016; Sosibo et al., 2022). Hence, I focus here on the hunting and use of forest-dwelling, vertebrate mammal species by rural communities in the Eastern Cape.

Harvesting bushmeat, as with any other natural resource, occurs in a complex social-ecological system (SES). Bushmeat hunting and use includes a comprehensive range of ecological and socio-economic issues, underpins the need to use interdisciplinary approaches to further understand the relationships between human socio-economic status and the exploitation of natural resources (Ordaz-Németh et al., 2017; Van Velden, 2020; Afriyie et al., 2021). It is therefore imperative that we integrate social and ecological thinking to understand the drivers of bushmeat hunting and consumption; and to further develop strategies to reduce unsustainable harvesting of bushmeat (Junker, 2015; Van Velden et al., 2020; Stone and Stone, 2022). Most research on bushmeat hunting and use posits that this challenge is best tackled from a complex, adaptive systems (CAS) perspective (Preiser et al., 2018). The framing of SES studies as CAS has considerably strengthened the recognition that human systems and ecosystems are inextricably related (Preiser et al., 2018). Here I view bushmeat hunting and use in the indigenous forests of the Eastern Cape as a complex SES and incorporate a CAS-based approach to further understand the drivers, patterns, and ecological impacts of bushmeat hunting and use.

1.1.1 The cultural significance of bushmeat hunting

Bushmeat hunting has a long history of predating the emergence of *Homo sapiens* (Reperant et al., 2012; Gaffney et al., 2021). Bushmeat hunting is considered one of the multiple factors leading to the mass extinction of megafauna during the Holocene period (Ripple et al., 2015; Ben-Dor and Barkai, 2024). Between the Upper Paleolithic and the Mesolithic periods, before agriculture emerged and livestock was domesticated, bushmeat hunting became a fundamental element of hunter-gatherer civilizations (Barrett and Armelagos, 2013; Hussain and Brusgaard, 2024). Hussain and Brusgaard (2024) further revealed that even as agriculture and animal domestication emerged, bushmeat hunting remained an integral source of food. Bushmeat hunting remains a deeply cultural activity for many human populations globally (Ripple et al., 2016). People hunt for food security, nutritional balance, employment, cash income, medicinal remedies, ceremonial and spiritual cleansing, and cultural practices (Figuié et al., 2020).

Bushmeat hunting is a culturally significant activity with substantial social implications, playing a crucial role in the cultural practices and traditions of numerous hunting communities globally (Stone and Stone, 2020; Van Velden et al., 2020; Torres et al., 2021). Lew-Levy et al. (2017) reported that hunting plays an integral role in the cultures of different communities with hunting skills passed from generation to generation. They further explained that in most

hunting communities, children are taught how to hunt by closely related males; children may also accompany their fathers on hunting trips or check on traps. In many countries, bushmeat hunting is not only for livelihood but also for cultural significance requiring young men to prove their manhood through hunting (Tadie and Fischer, 2013, Evans et al., 2020; Torres et al., 2021). Although not as common as men, women may also play an active role in bushmeat hunting (Tickle et al., 2024). In the Serengeti, Lowassa et al. (2012) reported that women used machetes to kill wildebeest and zebras passing through their homesteads during the annual migration. They further mentioned that women may also play a strong indirect role in bushmeat hunting by persuading men to go hunting. In the region, women generally preferred men who hunted both as spouses and casual partners, and women sometimes referred to non-hunting men as useless (Lowassa et al., 2012).

Lee et al. (2020) also acknowledged the cultural importance of bushmeat hunting in societies of traditional indigenous people around the world. They mention that in a village in Gabon, bushmeat is associated with traditional ceremonies and rituals, such as men's circumcision. In Equatorial Guinea, Kümpel (2006) demonstrated the cultural importance of bushmeat, mentioning that some species are considered to have magical or medicinal properties, and hence their market value is increased. Many cultures still employ traditional medicinal practices that include animal-derived remedies, and bushmeat consumption often fulfills both nutritional and medicinal roles (Alves and Alves, 2011; Lee et al., 2020). In southern Africa, there is a huge demand for animal-derived traditional medicines (locally referred to as muti) (Williams and Whiting, 2016; Khumalo et al., 2021; Nurse, 2023), supporting the second largest traditional medicine market in Africa (Whiting et al., 2013; Mothibe and Sibanda, 2019; Khumalo et al., 2021).

Cultural taboos are defined as activities that are forbidden or sacred based on cultural or religious beliefs (Gao, 2013; Morsello et al., 2015). Cultural taboos pertaining to certain wild animals have been documented globally (Obioha et al., 2012; Morsello et al., 2015; Bachmann et al., 2020). In Gabon, Starkey (2004) and Walters et al. (2015) reported a variety of forbidden species, including carnivores (leopard, *Panthera pardus*), yellow-backed duikers (*Cephalophus sylvicultor*), tortoises (*Kinxys* spp.), and certain primates. Starkey (2004) further mentioned that in certain cultures in Gabon, women are not allowed to consume meat from carnivores and primates, especially when pregnant. In Equatorial Guinea, it is culturally taboo for women to eat meat from crowned guenon (*Cercopithecus pogonias*) and African palm civet

(*Nandinia binotata*), as it is said to cause infertility and should only be consumed by elderly men (Van Vliet and Mbazza, 2011). According to Wiafe et al. (2023), in Central Ghana, it is taboo to hunt and consume colobus monkeys (*Colobus vellerosus*) and Campbell's monkeys (*Cercopithecus campbelli lowei*), as they are considered the children of the gods who protect the villages. Cultural taboos regarding certain species may be used as traditional conservation efforts (Jimoh et al., 2012; Bachmann et al., 2020).

However, Van Vliet and Mbazza (2011) argued that cultural taboos do not necessarily reduce the hunting level of taboo species, as some individuals who do not adhere to these beliefs may still engage in hunting, and others may unintentionally capture taboo species in traps when non-specific hunting methods are employed. In some cases, these taboos can be selectively ignored, especially when economic pressures or the scarcity of alternative resources outweigh cultural constraints (Bennett et al., 2010; Bachmann, 2023). Furthermore, the use of non-selective hunting techniques, such as snares or indiscriminate hunting with dogs, can inadvertently target taboo species, making it difficult to fully regulate hunting practices based on cultural norms (Bachmann, 2023). This highlights the complexity of managing bushmeat hunting, where cultural beliefs, economic incentives, and hunting methods intersect in shaping resource use (Lindsey et al., 2013).

1.1.2 Drivers and importance of bushmeat hunting

The hunting of wild animals for food has been the culture of indigenous people throughout the world for millennia (; Lengton 2012; Harris et al., 2021). However, growing concern has developed in recent years as the harvest level has become unsustainable in many regions globally (Ripple et al., 2016; Koné et al., 2023). The hunting of wildlife for human consumption is presently deemed a major threat to the conservation of biodiversity, particularly in tropical forests where extraction often exceeds production rates (Ripple et al., 2016; Fa et al., 2022). Local-level hunting of bushmeat is shaped by culture and socio-economic contexts (Luiselli et al., 2017; Chausson et al., 2019; Zyambo et al., 2022).

Throughout the tropical regions of Africa, a plethora of studies show that the increasing motivation for hunting is not for local household use but to supply the increasing demand for animal protein by urban populations (Wilkie et al., 2016; Van Vliet et al., 2017; Fa et al., 2022). However, numerous studies from the region have shown that bushmeat is frequently the most accessible source of animal protein and plays a vital role in household diets (Nasi and Fa, 2015;

Van Vliet et al., 2017; Brittain et al., 2022). Thus, for many rural people, bushmeat consumption is a matter of survival due to limited alternatives. However, culture plays a significant role, for example in Nigeria, Friant et al. (2015) found that a vast majority (85 %) of the community preferred bushmeat over domestic meat, with 75 % of the participants hunting for both selling and consumption purposes. They also indicated that only 5% of the participants hunted exclusively for income; these participants reported that they would choose not to hunt if they had an alternative source of income.

Rogan et al. (2018) assessed socioeconomic drivers of bushmeat use in southern Africa and reported that rural households with permanent employment were 1.6 times more likely to hunt than unemployed households, with seasonal employment having the strongest correlation with the likelihood of hunting, followed by full-time employment. Based on these findings, it was concluded that Okavango Delta hunters take advantage of the opportunity to acquire profitable and low-cost resources that they neither depend on for their subsistence nor as a primary source of income. Contrary to the findings of Rogan et al. (2018), Brashares et al. (2011) assessed the economic and geographic drivers of wildlife consumption in four African countries (Cameroon, Ghana, Madagascar, and Tanzania), and revealed a weak negative interaction between household wealth and wildlife consumption. The study further revealed that less-wealthy households consumed more bushmeat in rural settings, whereas wealthier households showed higher consumption rates in urban settings. It has been argued that bushmeat hunting and consumption is largely for poverty mitigation and survival, but in many parts of the world, hunting is an opportunistic activity performed by both the poor and the wealthy (Kümpel et al., 2010; Rogan et al., 2018; Oliveira et al., 2023). Wealthier community members may be more able to afford superior weaponry or take on the financial risks of hunting that poorer members (e.g. Damania et al. 2005; Knapp 2012, Travers 2019). Additionally, they may have greater access to transportation and networks that facilitate hunting in remote areas, further increasing their advantage (Lindsey et al., 2011). In many parts of Africa, urban households consume more bushmeat than rural households because bushmeat is perceived as healthier, delicious, or cheaper than domestic meat (Van Vliet et al., 2011; Van Vliet et al., 2015; Fargeot et al., 2017; Luiselli et al., 2019).

According to Van Vliet and Mbazza (2011), the increasing demand for bushmeat protein in urban areas is a key driver of bushmeat hunting globally. As Africa has the fastest population growth globally, the demand for animal protein is increasing (Lindsey, 2013; Hall et al., 2017).

In many parts of sub-Saharan Africa, there is a struggle for food production (especially animal protein) to meet the demands of the growing population (Myers et al., 2017); this in turn increases the demand for bushmeat (Rogan et al., 2018; Oliveira et al., 2023). Bushmeat market research (e.g. Nasi et al., 2008; McNamara et al. (2019) conducted in central Africa revealed that urban households consume less bushmeat than rural households. This was confirmed by Wilkie et al. (2016), who showed that rural bushmeat consumption largely outweighs urban consumption in every country in central Africa. On the other hand, Van Vliet et al. (2015) suggested that even though per capita bushmeat consumption was low among urban users, combined urban consumption was higher than combined rural consumption because of the high population density of urban areas.

While assessing the importance of bushmeat in Tanzania, Nielsen (2006) noted that hunters caught an average of 420 g of meat a day and that only 10 % of the total catch of all hunters was sold; the rest was consumed in the household. Nielsen (2006) deemed bushmeat as not an important source of protein in Tanzania, as only an average of 22 % of meat-containing meals of the cooperating hunters contained bushmeat, and none of the non-hunters declared eating bushmeat. This could be attributed to hunters understating that catch or that wildlife in the area has been largely depleted. Contrary to these findings, Kümpel et al. (2010) found bushmeat to be an important component of the daily livelihoods of the hunting community and the public. Eighty percent of households had at least one hunter, and 60 % of men hunted to some degree, with one-third hunting daily. Although hunting was perceived as a dangerous activity, it was deemed necessary as a source of income and survival. In Gabon, Coad et al. (2010) observed that 64 % of men in the two villages surveyed hunted to some degree, and of the total biomass of animals hunted more than 40 % was eaten, 19 % of the meat was sold locally, 31 % was sold to external traders, 4 % was used in traditional ceremonies, and 2 % was given to another household. In the absence of alternative proteins, bushmeat is an important part of rural livelihoods in many African countries.

Bushmeat hunting occurs throughout South Africa. This practice is performed discretely as it is illegal to hunt outside formal hunting reserves. Until recently, research on the drivers and importance of bushmeat hunting in South Africa has been limited (Martins and Shackleton, 2019). The handful of studies that present results on the drivers or motivations behind bushmeat hunting indicate that hunting is a primary driver of poverty, culture, traditional medicine, sport, and recreation (e.g. White, 2004; Hayward, 2009; Shackleton et al., 2007; Kaschula and

Shackleton, 2012; Manqele et al., 2018; Van Velden et al., 2018; Young et al., 2018; Martins and Shackleton, 2019; Nieman et al., 2019; Sosibo et al., 2022). These studies show that bushmeat hunting in South Africa is not an important source of household livelihood or subsistence; as hunted meat is not taken back to the homestead but is eaten by the hunters in the field. (White, 2004; Manqele et al., 2018; Sosibo et al., 2022).

1.1.3 Bushmeat and emerging human infectious diseases

Contact with wild animals, including hunting, butchering, and pet keeping, may lead to the transmission of diseases that have potentially serious consequences for the health of both individuals and communities (LeBreton et al., 2016). Emerging infectious diseases (EIDs) are defined as human diseases that are either newly discovered or are increasing in incidence or geographic range (Kurpiers et al., 2016). Kurpiers et al. (2016) further revealed that EID emergence is accelerating, with over 300 distinct events recorded in the last six decades and more than 35 new infectious diseases emerging since 1980. More than 75% of EIDs found in humans are of zoonotic origin (Jones et al., 2008; Weiss et al., 2022); meaning that the pathogen originates in animals and is transmitted to humans (Recht et al., 2020). Although most zoonotic pathogen spillovers occur in domestic animals, like livestock, most (72%), zoonotic EIDs occur in wildlife species (Jones et al., 2008).

According to Weiss et al. (2022), approximately three-fourths of EIDs in humans are caused by zoonotic pathogens. Some of these pathogens are responsible for global mortalities like HIV-1 and -2 and the influenza virus, while others may cause limited deaths but result in high case fatalities, for which there are no effective cures or vaccines (e.g. Ebola virus, severe accurate respiratory syndrome [SARS] and hantaviruses) (Recht et al., 2020). The spread of zoonotic diseases from animal hosts to humans may occur in various ways, including (i) common vectors, such as mosquitoes for malaria, (ii) indirect contact, such as exposure to rodent faeces and (iii) direct contact with animals through consumption, bites, scratches, and body fluids (Kurpiers et al., 2016). Furthermore, Rahman et al. (2020) showed that the risk for the emergence of new zoonotic agents from wildlife depends largely on three factors: (i) the diversity of microbes in a region (“zoonotic pool”); (ii) the effects of environmental change on the prevalence of pathogens in wild populations; and (iii) the frequency of human contact with wildlife reservoirs of potential zoonoses.

There is evidence of an intense link between infectious diseases and anthropogenic ecosystem disturbances such as land-use changes, habitat fragmentation, and biodiversity loss (Gottdenker

et al., 2014; Recht et al., 2020). In their review, Gottdenker et al. (2014) concluded that the most common land use change types related to zoonotic disease transmission were deforestation, habitat fragmentation, agricultural development, irrigation, and urbanization. These anthropogenic environmental disturbances alter the usual functioning of the ecosystem leading to disruptions in food-webs, changes in host-pathogen interactions, and mixing of gene pools, resulting in increased pathogen genetic diversity (Recht et al., 2020). As land use changes occur, humans are increasingly exposed to wildlife species, which in turn may lead to an increase in bushmeat hunting and consumption, subsequently leading to disease outbreaks such as Ebola and HIV, as observed in some sub-Saharan African countries.

Pathogen spillover from bushmeat may occur through consumption (Kurpiers et al., 2016); though high risks are associated with exposure to body fluids and feces during butchering and handling (Paige et al., 2014). Increased interactions between humans and wild animals present opportunities for zoonotic disease transmission; this is especially the case when handling and butchering primates, as these species have a close genetic relationship with humans (Kurpiers et al., 2016). In many parts of sub-Saharan Africa, humans come into frequent contact with primate species, promoting the potential transfer of zoonotic diseases from species like chimpanzees (*Pan troglodytes*) and sooty mangabeys (*Cercocebus atys*) (Peeters et al., 2002). According to Weiss et al. (2022), both HIV-1 and HIV-2 are of zoonotic origin; with the closest similar relatives found in chimpanzees and sooty mangabeys (Weiss et al., 2022).

1.1.4 The contribution of non-timber forest products to rural livelihoods

Sustainable extraction of non-timber forest products (NTFPs) is promoted to achieve poverty alleviation and biodiversity conservation goals (Pandey et al., 2016; Fromentin et al., 2023). Many advocates of the 'NTFP-strategy' point out the importance of NTFPs to rural communities through the provision of food, fuel, medicine, construction material, income and employment (Magrabi et al., 2023). To a large extent, forests are mostly situated in rural and remote areas, often underdeveloped (Musakwa et al., 2020; Shackleton and de Vos, 2022). Hence, it is not surprising that communities living in these areas are faced with numerous livelihood challenges, such as food insecurity, unemployment, and poverty (Musakwa et al., 2020). Newton et al. (2016) assessed communities living in tropical forests and suggested a typology of people-forest relations that provides justice to the diverse dependencies of NTFPs. They distinguished between (i) communities residing within forests, for whom forests offer the main source of livelihood, (ii) farming communities that depend on forests as a supplement to

their livelihoods, and (iii) communities living further away from forests that make their livelihoods from commercial forest activities like artisans and forestry employees. The distinction between these communities and their livelihoods provides a more realistic and clearer picture of the relationship between people and forests. Shahi et al. (2022) explained this by showing that people's reliance on forests may change in different settings and that there is no single classification of "forest-dependent" people.

Shackleton et al. (2007) revealed the importance of forests to the livelihoods of rural communities in South Africa, with five valuable roles for rural people: (i) they are the source of daily requirements, (ii) they serve in cash-saving, (iii) they serve as a safeguard or safety net during periods of adversity; (iv) forest products also play significant cultural and (v) income roles for rural communities. Geldenhuys (1999) further showed that over 93 % of the canopy and 77 % of the sub-canopy tree species are used in indigenous forests throughout South Africa. Table 1 illustrates the essential requirements provided by forests; firewood is the most extracted resource from indigenous forests in the region (Shackleton et al., 2007). This is closely followed by the extraction of medicinal plants, which is a multi-million rand industry in South African formal and informal markets (Shackleton and Campbell, 2007, Maroyi, 2022). Shackleton et al. (2007) found that other forest products used included grasses, mushrooms, wild fruit and nuts, wild spinach, honey, bushmeat, and fish.

Shackleton and Pandey (2014) argued that resources from indigenous forests can also be used as cash-saving strategies. The use of forest resources allows households to save scarce money that can be used toward other domestic needs, such as education for children, farming tools, and capital for revenue production activities (Adam and Shackleton, 2016). NTFPs for saving cash are mostly observed in poorer households, as these households have lower total incomes than wealthier households (Paumgarten and Shackleton, 2011). Adam and Shackleton et al. (2011) further revealed that the daily use of NTFPs for energy, shelter, food, and medicine differs from the use of forest resources during times of adversity.

In times of instability, scarcity, or stochasticity, rural households may use NTFPs as a 'safety net' or gap-filler (Cheng et al., 2017). During these times, households are faced with unexpected shifts in the financial, social, or climatic settings in which they exist and operate (Shackleton and Pandey, 2014). For example, the passing or retrenchment of a household head or employee, environmental shocks that may lead to crop loss or livestock death, major financial adjustments, or the unforeseen rises in the prices of primary foodstuffs and goods

(Paumgarten and Shackleton, 2011). During such periods, forests serve as "natural insurance" in the form of alternative revenue sources and subsistence to help residents cope with shocks (Dokken and Angelsen, 2015). Shackleton et al. (2011) report that the use of forest resources as safety nets can take three forms: (i) using NTFPs that are usually not used by a specific household, (ii) increasing consumption of NTFPs already used by the household, or (iii) short-term trading of NTFPs in local or regional markets.

Table 1.1: The range of forest resources used by rural communities (From: Shackleton, 2004)

Products from woody plants		
• Fuelwood • Charcoal • Kindling • Browse for livestock • Mulch/compost	• Construction timber-poles for houses, kraals, fences • Utensils and tools (Spoons, axe handles) • Carving wood • Wood for furniture • Fruits/seeds	• Wood roses • Bark fibre of weaving • Barks, roots and leaves for medicine • Twig bushes • Sap for beverages • Sap/oil for dyes and medicine
Products from grasses/reeds		
• Thatch • Weaving fibre (baskets, ropes mats)	• Fodder/grazing	• Brushes
Mushrooms		
• Food	• Medicine	
Fruits, nuts and seeds		
• Fruits for food • Fruit for juice • Fruit for alcoholic beverages	• Kernels/nuts for eating • Kernels/nut for oils • Kernels/nuts for medicine	• Jams • Seeds for decorations, beads, dancing rattles, etc.
Herbaceous plants		
• Edible herbs	• Medicine	• Decorative flowers
Animals and animal products		
• Insects for food • Birds and bird eggs for food • Fish for food • Animals for food	• Animal skins for leather and cultural artefacts • Animal fats and products for medicine	• Honey and beewax

Bushmeat is an important global component of NTFP (Schulte-Herbruggen et al., 2013; Lee et al., 2020). Most communal lands have weak enforcement of hunting regulations which allows bushmeat to remain an accessible resource for many rural communities, which makes busmeat an important resource for many disadvantaged households (Ripple et al., 2016; Sackey et al., 2023). Nasi and Fa (2015) reported that the safety net functions of bushmeat are vital to the livelihoods of poor communities, particularly in areas with little opportunity for transformation. The safety net functions of bushmeat were also demonstrated by Schulte-Herbruggen et al. (2013), who reported that the hunting and use of bushmeat peaked in the

agricultural lean seasons compared to the farming seasons. This shows that in times of financial stress and unemployment, rural communities resort to bushmeat as a safety net. This was also shown in McGarry and Shackleton (2009), where, in the absence of alternative protein sources, children resort to bushmeat as a protein source.

Recent studies have highlighted the importance of bushmeat as a NTFP for the livelihoods and food security of many rural communities (Schulte-Herbruggen et al., 2013; Van Gils et al., 2019; Ndumbe et al., 2022). Bushmeat can be consumed by households or traded for cash income in local or urban markets (Shackleton et al., 2011). Children have also been documented hunting birds, rodents, and small mammals as they play, herd cattle, or collect water and firewood from streams and nearby forests, contributing to protein and vitamin needs (McGarry, 2008; McGarry and Shackleton, 2009; Peterson et al., 2017; Douno et al., 2021). In many countries, poor, rural households have limited access to alternative protein sources, increasing their dependency on bushmeat (Kümpel et al., 2010; Friant et al., 2020)

1.1.5 Bushmeat in rural livelihoods

Rural communities around the world are faced with several developmental issues, with poverty one of the major concerns (Cawthorn and Hoffman, 2015; Stone and Stone, 2022). There is a strong relationship between biodiversity loss and poverty, as economically deprived and politically marginalized communities depend on wild species from local ecosystems for their livelihoods (Lindsey et al., 2020; Nguyen and Jones, 2022). As documented in numerous studies, poverty and biodiversity-rich areas are geographically parallel (Ripple et al., 2016; Dell et al., 2020; Fonkow, 2023). Biodiverse areas are centered in and around rural communities where livelihoods depend on the natural wealth embedded within these landscapes (Shackleton et al., 2007; Barrett et al., 2011; Campos-Silva et al., 2021). There is an expectation that formal conservation actions should benefit surrounding communities, assist in protecting livelihoods, and present minimum risk to the poor (Turner et al., 2012; Baldock, 2020; Foya et al., 2023). Yet most conservation efforts have not efficiently addressed developmental and poverty alleviation goals (Adams et al., 2010; Bachmann et al., 2020; Stone and Stone, 2020; Fromentin et al., 2023). To date, there is inadequate analysis to inform decision-makers about the role of conservation in alleviating poverty and socioeconomic development (Fromentin et al., 2023).

Bushmeat plays a significant and direct role in the livelihoods and food security of millions of people around the world (Van Vliet et al., 2011; Booth et al., 2021; Jenkins et al., 2024). Several studies have shown that even though there has been much discussion around bushmeat hunting and trade, there is still a dearth of knowledge about its role in rural livelihoods (Kansiime, 2012; Kümpel et al., 2010; Martins and Shackleton, 2019; Sikhunyana et al., 2020; Musumba et al., 2022). They further comment that without such evidence, policymakers are unable to offer clear, developmental or conservation responses to the bushmeat issue. To date, much research has largely focused on the impact of bushmeat hunting on biodiversity. Ripple et al., 2016; Lindsey et al., 2011; Benítez-López et al., 2017; Evans et al., 2020), and sustainable bushmeat hunting (Kümpel et al., 2010; Van Vliet and Nasi; 2015; Brittain et al., 2022) have been studied, leaving a gap in knowledge on the socioeconomic drivers and motivations behind bushmeat hunting and use.

1.1.5.1 Bushmeat in rural livelihoods: the situation in Africa

In the case of bushmeat hunting and use, numerous studies in many parts of central and western Africa have demonstrated the importance of bushmeat to rural communities (De Merode et al., 2004; Coad et al., 2010; Schulte- Herbruggen et al., 2013; Van Velden et al., 2020; Foya et al., 2023). In the region, bushmeat plays an important role in the subsistence and livelihoods of many communities (Alexander et al., 2015; Van Gils et al., 2019). Various studies that evaluated the role of bushmeat in the food security of people in countries around the Congo Basin rainforests (e.g. Equatorial Guinea, DRC, Cameroon, Gabon, Republic of the Congo, and Central African Republic, have reported bushmeat as the main source of protein for both rural and urban societies (Van Vliet and Mbazza, 2011; Fargeot et al., 2017; Booth et al., 2021; Brittain et al., 2022).

In Africa, the majority of research on bushmeat hunting is centred in the tropical rain forests, where large amounts of bushmeat are harvested annually, and bushmeat markets play an important role in local economies (Taylor et al., 2015). Current bushmeat hunting rates in African tropical rainforests have been deemed unsustainable because extraction largely exceeds species production rates (Mbotiji, 2002; Nasi et al., 2011; Fa et al., 2022). Predictions from the past decade show that if harvesting continues at these rates, there will be a significant decline in wild protein by 2050, resulting in dire consequences for both the wildlife and the people who rely on it (Robinson and Bennett, 2000; Fa et al., 2002; Koné et al., 2023)

In the drier biomes, growing bushmeat research from southern and eastern Africa has shown that bushmeat is a valuable resource for many communities throughout the regions (e.g. Mfunda and Røskaft, 2010; Wilkie et al., 2016; Nielsen et al., 2016; Manqele et al., 2018; Martins and Shackleton 2019; Van Velden et al., 2020; Stone and Stone, 2020; Sosibo et al., 2022; Foya et al. (2023). Although not as much as in the tropics, the consumption of bushmeat by communities in Africa savannas has been documented. A recent study by Oluoch (2024) showed that in Kenya, around 14 kg of bushmeat is consumed on a monthly basis by 80% of households, spanning both rural and urban settings. In a rural village in Botswana, 46% of households consumed >18 kg of wild-type protein monthly (Kasimba et al., 2019). In Zimbabwe, Lindsey et al. (2011) observed that bushmeat hunters were generally young (20-30 years), unemployed, had low livestock ownership, and had poor food security.

In Madagascar, it is estimated that 90% of rural households have an active hunter, with all households consuming wild meat 2 - 8 times a month (Golden, 2009; Merson et al., 2019; Rakotoarivony et al., 2022). In 14 rural villages in north-eastern Madagascar, Golden (2009) found that 95 % of respondents consumed bushmeat in the past year. In the region, 86% (12 of 14) of the surveyed communities consumed the white-fronted brown lemur (*Eulemur albifrons*), bamboo lemur (*Hapalemur griseus*), black and white ruffed lemur (*Varecia variegate*), indri (*Indri indri*), and fossa (*Crypoprocta ferox*), which are all formally protected species that should not be hunted. Merson et al. (2019) further highlighted that the hunting and consumption of these protected species is not a matter of taste preference but is driven by poverty. Rakotoarivony et al. (2022) added that bushmeat hunting in the region is unsustainable for most forest species. As harvesting becomes unsustainable, hunting yield will be compromised, and with the weak economy in Madagascar, rural households will be left with limited protein options as bushmeat will be depleted and they will not be able to afford domestic meat.

Literature from past decades has shown that many rural communities on the African continent use bushmeat for survival and cash income (e.g. Garder and Davies, 2014; Merson et al., 2019; Rakotoarivony et al., 2022). Consumption and trade are key drivers of bushmeat hunting in the region, followed by culture. For numerous households throughout the continent, bushmeat is the sole source of protein, as they do not own livestock or are unable to purchase domestic meat products. The lack of development in many rural communities in Africa has caused

further poverty and food insecurity and hence increased reliance on wildlife products such as bushmeat.

1.1.5.2 Bushmeat in rural livelihoods: the situation in Asia

Rural communities around the world are largely reliant on bushmeat for their daily livelihoods and nutrition, and Asia is no exception, where rural and traditional communities around the continent depend on hunting for subsistence and livelihoods (Lee et al., 2014; Ripple et al., 2016; McEvoy et al., 2019). Consumption, trade, culture, and recreation are said to be the key motivations behind bushmeat hunting in Asia (Scheffers et al., 2012; Lee et al., 2014; Harrison et al., 2016; Zhou et al., 2022). Various studies have highlighted the cultural significance of bushmeat hunting in Asia, revealing that most rural communities use meat from wild animals in various celebrations and rituals (Scheffers et al., 2012; Pattiselanno and Nasi, 2015; Lee et al., 2020). According to Harrison et al. (2016), hunting and deforestation have led to the local extinction of many large mammals (e.g. the giant tapir *Tapirus augustus*, Chinese elephant *Elephas maximus rubridens* and the Caspian tiger *Panthera tigris tigris*), except a few hunting-tolerant species. Furthermore, they mentioned that throughout the region, most large mammals have suffered considerable population losses over much of their natural range. The preference for large mammals has led to the unsustainable harvesting of larger game species, which has contributed to the enormous reduction of these species in the region (Zhou et al., 2022).

In the tropical forests of Southeast Asia, rural people hunt for three basic, interconnected reasons: culture, food, and income (Scheffers et al., 2012; Harrison et al., 2016). In a rural village in the Philippines, hunters sell almost half of their catch, and the other half is consumed in celebrations (Pattiselanno and Nasi, 2015; Lee et al., 2020). However, they mention that sale appears to supersede consumption because most of the hunters have regular customers who purchase bushmeat they catch. In Myanmar, Roa et al. (2010) reported that farming was the primary occupation for the interviewed hunters (96 %); 45% of the village respondents listed agricultural practices as the highest source of income, followed by NTFPs (31%) and bushmeat hunting (24%). They further showed that income was the primary driver of hunting, as the preferred or targeted species were of high economic value. In the remote forest areas of Southeast Asia, Van Vliet et al. (2011) reported that the consumption of bushmeat is high because it is priced less than domestic meat. Yet, due to recent anthropogenic forest destruction and an increase in human populations, a large depletion of forest fauna has occurred in the region, and some people have been forced to shift from bushmeat to domestic meat (Lee et al.,

2020). Lee et al. (2020) further observed that bushmeat is still consumed in large quantities in the region, but it is now consumed as a luxury item by wealthy urban residents rather than by rural households.

It is widely accepted that large mammals have decreased significantly in the forests of the continent because hunters prefer larger species that provide more meat (Zhou et al., 2022). Wildlife plays an important role in the cultures of indigenous communities in Asia; many species are traditionally used for medicine and are consumed for spiritual and cultural reasons (Harrison et al., 2016).

1.1.5.3 Bushmeat in rural livelihoods: the situation in South America

In many rural areas around South America, bushmeat plays a fundamental role in food security, sustaining household economies, and supporting cultural practices and rituals (Van Vliet et al., 2017; Nielsen et al., 2018; Peros et al., 2021). In the Amazon region, research has largely focused on bushmeat hunting and its use by indigenous communities, who still continue to live a traditional lifestyle and depend on bushmeat as a vital part of their livelihoods (Van Holt et al., 2010; Torres et al., 2018; Groom et al., 2023; Lemos et al., 2024).

In the Brazilian Amazon, between 9.6 million and 23.5 million birds, reptiles, and mammals are harvested annually, corresponding to around 100 000 tons (Van Vliet et al., 2018; Garber et al., 2024). In economic terms, the amount of harvested bushmeat would represent an average annual market value of US$134 million (Van Vliet et al., 2018). Van Holt et al. (2010) used consensus analysis to assess hunting persistence in the livelihoods of communities in the Bolivian Amazon. They discovered that in rural communities in the region, bushmeat and fish were the main sources of protein for most households and that, among many households, domestic meat was infrequently consumed (< 10 times per year). The informants in their study reported that fish were consumed multiple times a week, bushmeat was consumed numerous times a month, and meat was consumed from domestic animals less than once a month.

It has been shown that approximately five million people in South America depend on bushmeat as a source of protein (Nasi et al., 2011; Ripple et al., 2016; Van Vliet et al., 2017; Santos et al., 2022). These communities are mostly in poor, rural communities that represent about 2% of the total population in the continent (Van Vliet et al., 2015). Furthermore, Lemos et al. (2024) explained that bushmeat contributes very little to the overall consumption of meat in urban communities throughout the continent and that the demand for bushmeat is likely to

decrease in the region. Due to a strong livestock and fisheries industry, and if the economy of South America continues to grow, the demand for bushmeat will further diminish. Nonetheless, in the Amazon region, bushmeat is still being harvested at unstainable rates, due to being the sole source of protein for many communities (Van Vliet et al., 2022). Although rural communities make up a small percentage of the human population, their impact on wildlife species in the tropical forests of the region is enormous.

1.2 Theoretical and conceptual framing

1.2.1 The bushmeat crisis

Direct exploitation and habitat destruction are the primary threats to the decline of vertebrate species globally (Hoffmann et al., 2010; Bellard et al., 2016; Ripple et al., 2016; Souza et al., 2022). Direct exploitation mainly arises from hunting pressure; hunting has influenced the extinction and near extinction of numerous mammalian species, particularly where species are harvested for food, medicine, or decorative purposes and to supply commercial markets (Nasi et al., 2008; Ripple et al., 2016; Souza et al., 2022). Ripple et al. (2016) demonstrated that the unsustainable anthropogenic hunting of wild terrestrial mammal populations represents a significant extinction threat to large mammal species, particularly in the tropical regions of South America, Asia, and Africa. The complex human-wildlife conflict scenario presented by the unsustainable exploitation of bushmeat in many settings has been recognized by many (e.g. Mfunda and Røskaft, 2010; Rogan et al., 2018; Ria, 2019). The threats presented to different wildlife species through hunting and the well-being of marginalized communities make bushmeat hunting an international development and conservation concern, warranting the phrase *bushmeat crisis* (Robinson and Bennett, 2002; Eves et al., 2008; Minteer, 2013; Zhou et al., 2021).

The worldwide bushmeat crisis is a complex problem to address, as it is closely linked to human challenges such as land-use changes, culture, emergent disease risks, and food insecurity (Nasi et al., 2008; Cawthorn and Hoffman, 2015; Friant et al., 2020; Trefon, 2023). The dynamic complexity of the bushmeat crisis underscores the need for an interdisciplinary research approach to direct bushmeat studies and policy (Blair et al., 2017; Peros et al., 2021). The approach should embrace *systems thinking* to recognize and examine the relations among complex system variables (Hill, 2015; Van Velden et al., 2020; Stone and Stone, 2022). To achieve sustainable bushmeat hunting, there is a need for dynamic frameworks and models to effectively understand this complex system. Using the social-ecological systems framework

(SESF) to systematize several key variables in the bushmeat crisis allows for a formal investigation of this complex human-wildlife interaction and the non-linear links between humans and wildlife to better understand system outcomes (Ostrom, 2009; Van Vliet et al., 2015).

The bushmeat crisis has arisen from human overexploitation of wildlife species (Robinson and Bennet, 2002; Norris et al., 2010; Mavah et al., 2022). The impact of uncontrolled harvesting is not only felt by the target species and their environments but, as unsustainability grows and hunting yields drop, by the hunter communities themselves (Ripple et al., 2016). Unsustainable harvesting of wildlife will ultimately lead to the depletion of many species, in turn resulting in escalated poverty and cultural impoverishment in communities that rely on wild meat for their daily livelihoods (Nasi et al., 2008; Coad et al., 2018; Lee et al., 2020). To address the bushmeat crisis as a SES, we must consider that linked human and ecological systems are complex adaptive systems (CAS) (Van Vliet et al., 2015; Preiser et al., 2018; Van Velden et al., 2020). Sandom et al. (2018) noted that uncontrolled harvesting of wildlife has transformed into an international catastrophe captivating the form of a critical threat to the food security of numerous communities as well as the direct existence of hundreds of animal species and transformed ecological webs within ecosystems. Understanding this SES as a CAS produces integrated knowledge about the variables within this complex system and how they are linked.

1.2.2 Ecological impacts of bushmeat hunting

Hunting is a disruptive process that triggers unforeseen effects on both target species and the overall structure of ecosystems (Nasi et al., 2011; Braga-Pereira et al., 2020). It disrupts ecological and evolutionary processes, potentially leading to a decline in biodiversity due to the loss of wildlife species, which serve as critical components of resource systems (wildlife populations) within social-ecological contexts (Ripple et al., 2016). Unsustainable hunting off-take not only affects the species being hunted but also disrupts their ecological roles, such as seed dispersal, prey relationships, and contributions to nutrient cycles (Shackleton et al., 2019). The loss of keystone species and ecosystem engineers within these resource systems has an especially significant impact, as they disproportionately affect ecosystem stability (Campos-Arceiz and Blake, 2011; Nasi et al., 2011; Budnukaeku and Ichendu, 2021). Larger animals are often the primary targets of hunters (actors) and are particularly vulnerable, and their decline is frequently reflected in local markets (Barnett, 2000; Ordaz-Németh et al., 2017; Fragoso et al., 2022). Apex predators play a crucial role in maintaining ecosystem balance through top-

down control, influencing trophic cascades and providing resources like carrion (Lindsey et al., 2013; Terborgh, 2010; Nieman et al., 2019). Their removal, as a result of unsustainable hunting, can lead to profound and often irreversible changes in ecosystem dynamics (Ripple et al., 2016; Western and Mose, 2021; Gore et al., 2020; Cheptarus, 2022), further altering the resource systems they once regulated.

The overhunting of small mammals which are also a key part of resource systems, can also disrupt ecosystems due to their essential roles in seed dispersal, forest regeneration, and functioning as prey for other species (Ripple et al., 2016; Van Gils et al., 2019; Van Velden et al., 2020). As actors, hunters exert pressure on larger species, this can lead to cascading effects within the resource systems, such as increases in smaller species due to reduced competition (Fa and Brown, 2009; Effiom et al., 2013; Bachmann et al., 2020; Nasi and Van Vliet, 2011; Thenell, 2018). This complex interplay between hunting pressure and ecological release illustrates the broad consequences of hunting on ecosystem dynamics. Studies on bushmeat hunting show that population densities of many mammals, particularly large species with low intrinsic growth rates, decline under high hunting pressure, leading to long-term disruptions in the ecological balance of the resource systems (Cullen et al., 2000; Rogan et al., 2017; Torres et al., 2021; Nasi et al., 2011; Ripple et al., 2016). Furthermore, hunting pressure also alters species' behaviours, such as evolving predator-avoidance strategies, which can reduce hunting success for natural predators and disrupt predator-prey dynamics within these systems (Fa and Brown, 2009; Deith and Brodie, 2020; Djagoun et al., 2023; Kiffner et al., 2014).

In response to these challenges, governance systems, such as the establishment of fenced protected areas, have been introduced as a conservation measure to manage wildlife populations and regulate hunting (Bennett et al., 2007; Pekor et al., 2019; Taylor et al., 2021). For example, in South Africa, fencing aims to limit human intrusion into resource-rich areas, seeking to protect vital resource systems (wildlife populations) (Hayward and Kerley, 2009). However, these governance systems are not without complications. Fences can restrict animal movements, reduce genetic diversity, and impair ecological connectivity within the resource systems, while failing to fully mitigate hunting pressures (Ripple et al., 2016; Pekor et al., 2019). Hayward (2009) notes that simply erecting a fence does not guarantee conservation success, especially when local communities (actors) perceive these protected areas as threats to their livelihoods or food security. This sense of ownership over wildlife often results in increased poaching, highlighting the complex interplay between governance systems, actors,

and the ecological outcomes within resource systems. Thus, more holistic interventions are needed to protect wildlife while balancing the socio-economic needs of local populations.

1.2.3 Sustainable wildlife use: addressing the bushmeat issue

A recent report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) highlights how sustainable use of wild species can benefit both people and nature, while also identifying the most effective policies to prevent unsustainable exploitation (Fromentin et al., 2023). This report integrates both social and ecological perspectives, emphasizing the importance of local ecological knowledge systems in ensuring the sustainable use of wildlife. Within the Social-Ecological Systems Framework (SESF), the sustainable use of wild species is influenced by the complex interplay between resource systems (wildlife populations), actors (hunters, local communities, and consumers), and governance systems (policies, hunting regulations, and protected areas). These components interact with various drivers, such as environmental, economic, cultural, and social factors, producing either synergistic or antagonistic effects on wildlife sustainability (Balachander et al., 2022).

Globally, mammalian species are experiencing severe declines, largely driven by anthropogenic pressures like bushmeat hunting, habitat fragmentation, and land-use changes (Ripple et al., 2016; Benítez-López et al., 2019; Gallego-Zamorano et al., 2020). These pressures are tightly linked to the food security and livelihoods of rural actors (local communities), who often rely on wildlife for nutrition and income due to limited alternative resources (Van Vliet and Mbazza, 2011). Within the SESF, these actors' dependence on wildlife can contribute to unsustainable resource extraction unless proper governance systems and community involvement are in place. Recent initiatives emphasize the convergence of conservation science, rural development, and local participation to create socially equitable and environmentally sustainable wildlife use strategies (Fromentin et al., 2023).

Sustainability, in theory, is achieved when wildlife extraction rates match or fall below production rates, maximizing the benefits of wildlife use without jeopardizing populations (Mbotiji, 2002; Hughes et al., 2023). However, achieving sustainable wildlife use necessitates attention to the socio-economic conditions of local actors, improvements in rural development, and robust law enforcement through governance systems (Redpath et al., 2013; Lemos et al., 2023). Redpath et al. (2013) note that conflicts often arise between rural development and wildlife sustainability, as short-term livelihoods may be negatively impacted by restrictions on

wildlife extraction. Thus, achieving sustainable use requires harmonizing ecological objectives with the socio-economic realities of resource users.

Bushmeat commercialization, particularly in urban markets, plays a major role in driving unsustainable harvesting practices, showcasing the broader interaction of resource systems with market dynamics (Miller-Gulland and Bennett, 2003; Lee et al., 2020; Willis et al., 2022). The demand from urban consumers, especially affluent ones who prefer bushmeat, has further amplified unsustainable harvesting in some regions, contributing to local species declines and threatening the broader ecological balance (Van Vliet et al., 2011; Smart et al., 2021). Throughout tropical regions, many local economies depend on the sale of bushmeat, which has turned this resource into a profitable enterprise (Schulte-Herbrüggen et al., 2013; Nielsen et al., 2017; Friant et al., 2020).

The consequences of unsustainable bushmeat hunting are significant, often resulting in species loss that can cascade through ecosystems and impact human communities in multiple ways (Koné et al., 2023). Addressing this requires a multidisciplinary approach that integrates local ecological knowledge, rural development, and strengthened governance systems to foster sustainable wildlife use. The SESF underscores the importance of recognizing and engaging with the local knowledge held by indigenous communities, which can offer insights into species conservation and help shape governance systems that are both effective and culturally attuned (Van Vliet and Nasi, 2015; Van Velden et al., 2020). Sustainable use, therefore, hinges on the effective integration of social and ecological systems, with resource systems, actors, and governance systems all playing critical roles in determining ecological outcomes.

1.2.4 Conceptual framework

Humans have coexisted with wildlife for millions of years, competing for habitat and resources (Nyhus and Tilson, 2010; Ripple et al., 2016; Fa et al., 2022). Yet, human-wildlife interactions have caused the extinction of many species, structural and functional changes to ecosystems, and the loss of human life, livestock, crops, and property (Nyhus, 2016; Conover and Conover, 2020; Abrahams et al., 2023). At most, conservation efforts are focused on mitigating conflicts between humans and wildlife (Pooley et al., 2017). On the other hand, social, economic, and political energies are invested in human development and social well-being (Stone and Stone, 2020). The one discipline studies plant and animal communities, while the others study human communities as if they were separate entities.

There is a growing awareness that approaches combining social and ecological knowledge should lead to more efficient and sustainable conservation solutions (e.g. Bennett et al., 2017; Ostrom and Cox, 2010; Fromentin et al., 2023). However, difficulties in aligning data sets, misperceptions, and misunderstandings between social and ecological disciplines continue to upset these efforts (Lischka et al., 2018; Deutsch et al., 2023). There is an obvious need for the integration of social and ecological studies into the management of human-wildlife interactions within social-ecological systems (Peterson et al., 2010; Balasubramaniam et al., 2021); as single-disciplinary efforts have failed to address this multidimensional challenge. To achieve proper wildlife conservation and sustainable use of wildlife species, we need to understand the complex drivers of human-wildlife interactions, as the value people place on these interactions has a significant impact on the survival of wildlife species (Lischka et al., 2008, Van Vliet et al., 2020).

Currently, there is a demand for research that either measures the effects of human actions on biological systems or the impacts of biodiversity loss on human well-being, to inform decision-makers and policy initiatives (e.g Frometin et al., 2022). For scientists to make adequate wildlife and developmental recommendations, a thorough understanding of social-ecological systems (SES) is required (Schlueter et al., 2012; Manyeni et al., 2024). Many researchers have acknowledged the nature of SESs, identifying them as complex, dynamic, adaptive, and uncertain systems with feedback (Gray et al., 2015; Preiser et al., 2018; Preiser et al., 2021). Biggs et al. (2015) further mentioned that such systems exhibit high levels of dynamic interactions and emergent behaviors. The original concept of SESs has progressed into a focused field of research that examines the symbiotic linkages between social and environmental change (Ostom, 2007) and how these symbiotic linkages advance sustainability goals through different systems (Partelow, 2018). Partelow (2018) further elaborates by mentioning that SES researchers ultimately want to understand how SESs can be sustainable for the ecosystem and livelihoods of people around the world.

The social-ecological systems framework (SESF) (Figure 1.1) provides a structured approach for analysing the complex interactions between social and ecological elements (McGinnis and Ostrom, 2014). The SESF is a conceptual framework of the various facets that can influence SES outcomes (Jones et al., 2019). It includes key subsystems such as resource systems (RS), resource units (RU), governance systems (GS), actors (A), interactions (I), outcomes (O), and related ecosystems (ECO), all of which are interlinked and influence one another (Jones et al.,

2019). The SESF can be employed as an instrument for the diverse research purposes. For example, governance systems (GS) shape actor behaviour (A), which in turn affects the resource units (RU) and broader ecological outcomes (O).

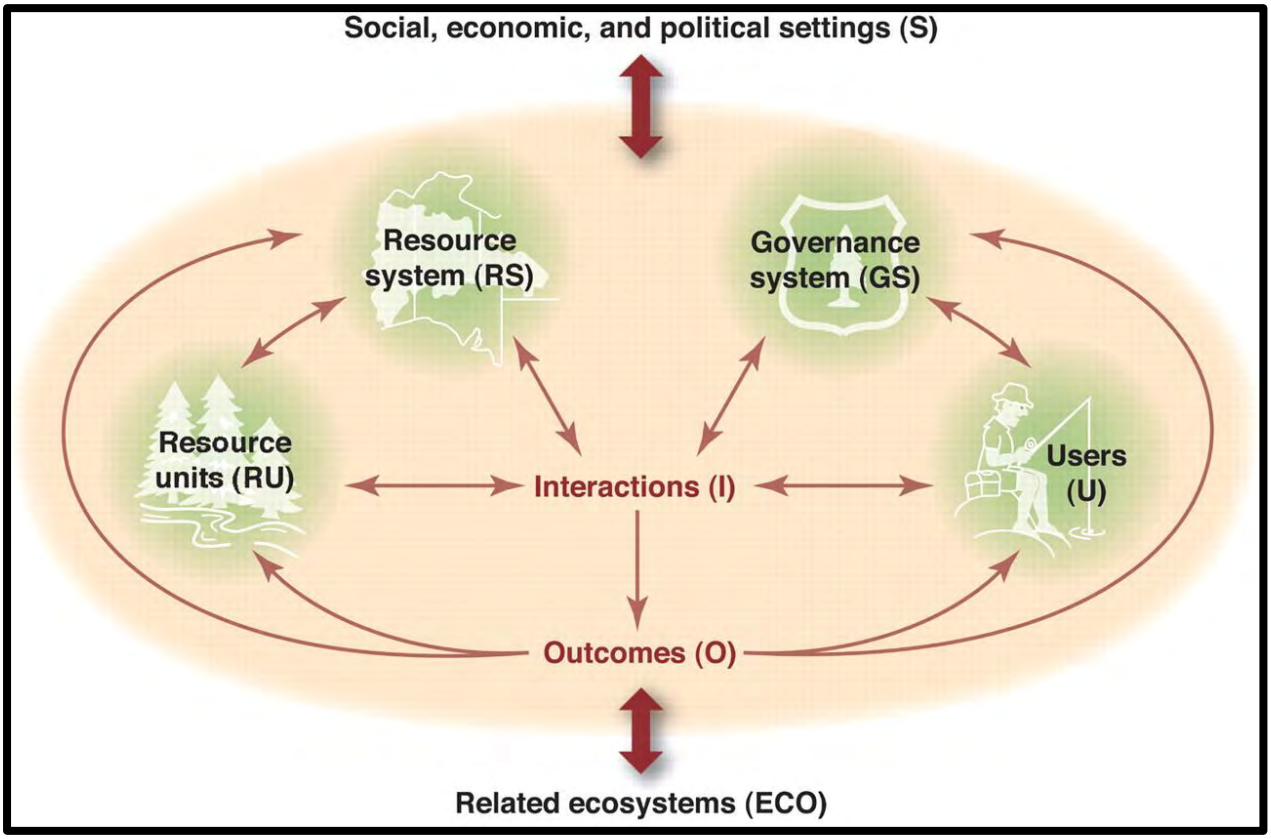

Figure 1.1: Core subsystems in a framework for analysing social-ecological systems (From Ostrom, 2009)

The current study uses the SESF to identify key pressures within the resource system (wildlife populations) and governance system (local hunting regulations), while also examining how actors' behaviours contribute to the observed discrepancies between hunter off-take numbers and wildlife population counts (Partelow, 2018). When employed as a tool for mixed-methods research, it provides (i) comprehensive and holistic analysis, (ii) multiple data types, and (iii) robust case study analysis (Partelow, 2018 By applying this framework, I can better understand the non-linear dynamics of bushmeat hunting and its ecological impacts, using it as a tool to explore how governance interventions may alter hunting practices and lead to more sustainable resource management outcomes.

1.3 Problem statement and study significance

Throughout Africa, bushmeat is used by both urban and rural communities as a source of protein to generate cash income and for culture. In these ways, it contributes to rural

livelihoods, food security, and cultural practices and identity in some regions. However, to date, research in South Africa on bushmeat hunting and use outside formal protected areas has been limited because the focus has been on large game hunted or poached within the boundaries of national, provincial, or private game reserves. However, a handful of published studies on bushmeat consumption in different parts of the country indicate that 30-60% of rural households attest to either hunting or consuming bushmeat at least once a year. This suggests significant demand and offtake, but the local and larger-scale drivers of bushmeat hunting and variations in demand across different contexts remain unknown. The same applies with respect to the ecological implications of bushmeat offtake for the species hunted and the ecosystems in which they are found and how broader land-use changes and transformation influence hunting and prey dynamics.

South Africa is a developing country with many rural, poverty-stricken communities. Many of these communities are surrounded or are in close proximity to forest patches that they use to different extents. Poverty is seen as one of the key drivers of bushmeat hunting globally, although literature from the rest of Africa also shows that taste preference, additional income, ornamental purposes, traditional and cultural practices, and sport are also motivations for bushmeat hunting. Studies in South Africa have revealed that people from urban areas occasionally visit communal forests to hunt; these people hunt by using different methods (guns) compared to local hunters. Yet little is known about the urban bushmeat demand; hence, it is also important to assess how often people from urban areas come to hunt or buy meat from local hunters and whether local headsmen or the general community permit outsiders to hunt in communal forests.

It is therefore imperative that interdisciplinary research on the ecological and socio-economic aspects of bushmeat hunting and use be conducted within rural communities using communal forests outside protected areas in South Africa. As a starting point, research should generate insights into (1) hunting practices (who hunts, species hunted and preferred, modes and frequencies of hunting and habitats in which hunting occurs or is avoided), (2) livelihood benefits (such as contributions to food security, income and culture/identity), (3) multi-scale drivers of hunting (why people hunt, when they hunt and how hunting has changed), and (4) direct and indirect effects on prey populations and local habitats. The knowledge and insights resulting from research into these aspects are necessary for assessing whether bushmeat offtake

is sustainable or not and also possible policy and management responses to promote conservation of the targeted species, ecosystems and local livelihoods.

1.4 Aims and objectives

The broad aim of this study was to assess the extent, nature, drivers, and implications of bushmeat hunting in rural communities located near indigenous forests in the Eastern Cape province of South Africa. This aim was achieved by addressing the following objectives and core questions for the study communities in the Eastern Cape.

Objective 1: To assess household NTFP use and the livelihood benefits associated with bushmeat hunting.

This study sought to evaluate the harvesting and use of NTFPs by rural communities surrounding forest patches in the Eastern Cape province, South Africa. I further assessed the livelihood benefits associated with bushmeat hunting by investigating bushmeat hunting by households in the region. Furthermore, I assessed the roles bushmeat plays in food security, income generation, and the traditional and cultural practices of rural communities in the study area. I also sought to obtain insights into the socioeconomic status of each household to enable comparisons between hunting and non-hunting households.

Objective 2: To determine hunting practices of rural communities in the Eastern Cape.

The purpose of this objective was to engage with hunters to gain insights into the motivations behind bushmeat hunting, the hunting methods employed and how they perceived the practice of hunting and the forest ecosystem as a whole. For this objective, I assessed the reasons why people hunt, who hunts, when hunting occurs, and whether people from urban/other places hunt in the area. I also investigated the species and number of animals per prey species that were hunted in the year before the study.

Objective 3: To evaluate mammalian species diversity under hunting pressure in the forests of the Eastern Cape, South Africa.

Bushmeat hunting has been reported to occur throughout the subtropical forests of the Eastern Cape. This is said to be a consequence of the high unemployment rates and poverty in the province which has contributed to an elevated reliance on forest resources. Most of the forests

in South Africa occur as small fragments in the Eastern Cape province. Despite their small size, the subtropical forests of the Eastern Cape are of high conservation value, harboring 14% of the country's mammal species. The harvesting of wildlife species in the forests in the region presents a major threat to many forest mammal populations, as overharvesting may lead to local extinction and an imbalance in the forest ecosystem.

In this study, I assessed the impact of bushmeat hunting on mammalian species in the forests of the Eastern Cape. In this objective, I use social-ecological methods to determine mammalian species abundance and richness under hunting pressure. The study also assessed the differences in mammalian species diversity between communal and protected forests.

Objective 4: To assess the sustainability of bushmeat hunting in the indigenous forests of the Eastern Cape, South Africa.

The ability to measure bushmeat hunting sustainability is vital when considering conservation and developmental objectives. Various studies conducted in tropical forests globally have used different models [e.g. Production model, Robinson and Redford (1991); Stock recruitment model, Bodmer (2003), and Harvest model, Bodmer (2003)]. These models have suggested unsustainable offtake in tropical forests (e.g. Robinson and Bennett, 2004; Van Vliet and Nasi, 2008; Van Vliet et al., 2015), although recent studies have clearly confirmed that hunting in tropical areas remains the primary source of protein and a key component of local livelihoods (Evans et al., 2020; Nasi et al., 2021; Groom et al., 2023). Several studies have reported that the static indicators used to assess the sustainability of bushmeat hunting do not perform well under realistic conditions, like the changes in mortality or birth rates (Van Vliet and Nasi, 2008; Zapata-Rios et al., 2009; Van Vliet et al., 2016). Furthermore, these models do not consider the connections between hunting and livelihoods, health, culture, and the local economy of the hunter. There is a need to incorporate complexity and stakeholder knowledge in measuring the sustainability of bushmeat hunting (Nyaki et al., 2014; Van Velden et al., 2020).

To assess the sustainability of bushmeat hunting, I employed data triangulation by integrating qualitative insights from hunter interviews with quantitative ecological surveys. Interviews provided insights into hunting effort, harvest rates, catch per unit effort (CPUE) and perceived trends in wildlife availability over 10 year period, while ecological surveys estimated mammal densities using line transects. By comparing local species densities with published data from other South African biomes, I evaluated population density trends of the five most hunted

mammal species. Triangulating hunter-interviews with ecological data allowed for an indepth understanding of whether or not current hunting prectices are sustainable.

1.5 Study area

The study was conducted in the Eastern Cape province of South Africa, the country's second-largest province, covering approximately 169,000 km², which accounts for 13.9% of South Africa's total land area (Fanteso & Yessoufou, 2022). The Eastern Cape was selected as the study area due to its extensive indigenous forest cover, as it contains nearly half of South Africa's remaining indigenous forests (Leaver, 2020) (Figure 1.2). These forests provide critical habitats for wildlife and serve as an important source of non-timber forest products (NTFPs) for local communities.

Furthermore, the Eastern Cape is the poorest province in South Africa, with over 70% of its population living below the poverty line (Leaver and Cherry, 2020). Rural communities in this region are highly dependent on NTFPs, including fuelwood, medicinal plants, and bushmeat, to support their livelihoods (Shackleton and Shackleton, 2004; Leaver and Cherry, 2020). Given this socio-ecological context, the province provides a relevant case study for examining the role of hunting within rural communities and evaluating whether it remains a significant socio-economic activity in the 21st century.

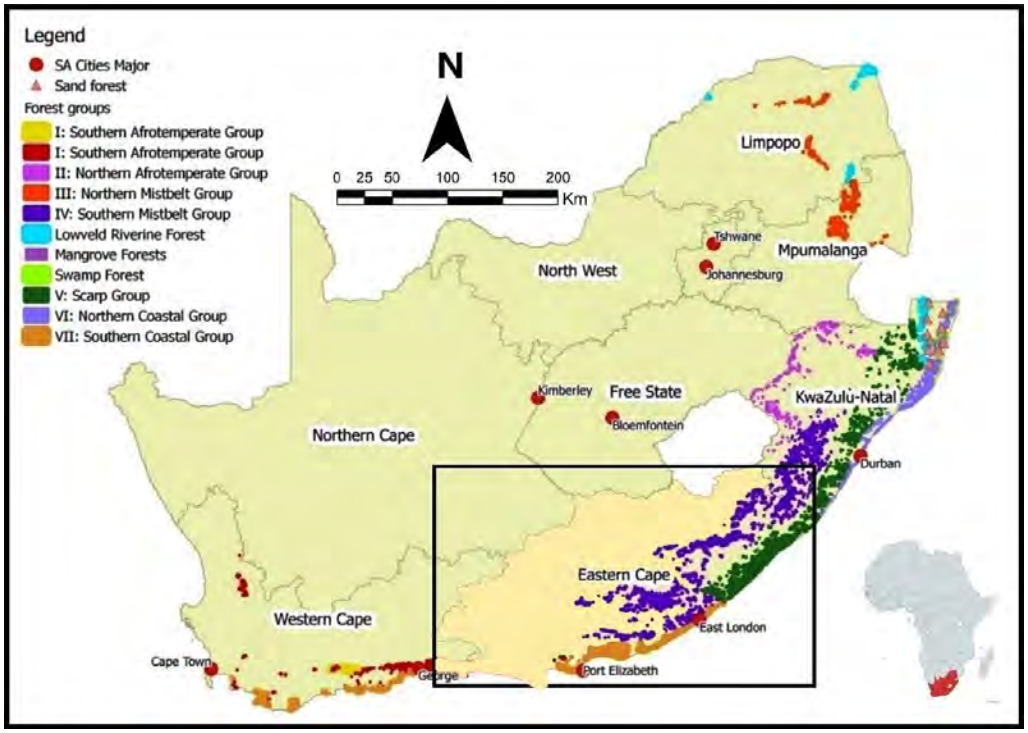

Figure 1.2: The distribution of indigenous forests in South Africa (Mucina and Rutherford, 2006).

The forests of the Eastern Cape are divided into inland (southern Mistbelt forest) and Coastal (Indian Ocean Coastal Belt forests). The southern inland Mistbelt forests are divided into two categories, i.e. the Amatole and Transkei Mistbelt forests. These forests are Afrotemperate forests dominated by a mixture of *Podocarpus* and *Afrocarpus* species (Wilson et al., 2017). Because of biogeography and paleoclimate, the distribution of these forests is patchy, mostly occurring on south-facing slopes (Lawes, 1990, Swart and Lawes, 1996, Lawes et al., 2000; von Maltitz et al., 2023). The Coastal forests in the province are divided into three categories i.e. East London, Transkei, and Mpondoland Coastal forests (Martins, 2016). Martins (2016) further described these forests as subtropical, low-stature, dense canopy forests on old, stabilized dunes fringing the coast. These forests are usually dominated by *Mimusops caffra* (Coastal red milkwood), *Sideroxylon inerme* (white milkwood), and *Dovyalis rotundifolia* (dune sour berry).

Using ArcGIS v10.8.2 and the South African land cover GIS layer map, I identified all indigenous forests in the Eastern Cape and employed the stratified random sampling method to select forest patches within the coastal and inland categories. Four Coastal protected forests, namely Umtiza (33°01'05.6"S 27°48'31.0"E), Hluleka (31°49'08.7"S 29°17'44.8"E), Silaka (31°39'33.3"S 29°30'04.0"E), and Mkambati (31°17'28.4"S 29°55'42.2"E), were randomly selected, while four neighboring communal forests, Fort Pato (33°00'21.3"S, 27°40'08.1"E), Tyityane (31°39'56.0"S, 29°28'52.8"E), Xutidwele (31°49'17.2"S, 29°16'28.2"E), and Msikaba (31°18'16.0"S, 29°52'03.8"E), of similar sizes, were also selected for comparative purposes. Additionally, two communal inland forests, Hogsback (32°36'21.4"S, 26°54'31.9"E) and Langeni (31°28'40.3"S, 28°27'05.9"E), were randomly selected from the inland Afromontane forests. However, there are no fenced, protected forests in this category, there was thus a total of 10 forests selected for the study. (Figure 1.3).

1.5.1 Characterization of the Eastern Cape southern Mistbelt forests

The Hogback and Langeni forests are situated within the inland Eastern Cape southern Mistbelt forest type, a region characterized by a unique blend of Afromontane and subtropical elements (Mucina et al., 2020). This forest type can be divided into two distinct categories: the Transkei Mistbelt forests, where Langeni forests are located, and the Amatole Mistbelt forests, which encompass Hogback forests (Gelderblom et al., 2003). Amatole forests are renowned for their exceptional species richness, with a flora predominantly composed of plants with Afromontane affinities, and many typical Afromontane species reach their southernmost limits in this region

(Hamann and Tuinder, 2012). The region experiences a cool climate, with a mean annual temperature of approximately 14°C, cold winters with frequent snowfall, and high rainfall of approximately 1 200 mm per year, mostly during summer (Omar et al., 2016). The geology of the area consists of sedimentary rocks from the Balfour Formation, which is part of the Beaufort Group (Coleman, 1999). Recent studies have highlighted the importance of these forests as biodiversity hotspots and carbon sinks, underscoring the need for continued conservation efforts (Gadow et al., 2016; Wiersum et al., 2006).

The Langeni forest is situated within the Transkei Afromontane forest, a fragmented ecosystem embedded in grasslands that is predominantly found on south-facing slopes in the interior of the former Transkei (Mucina et al., 2020). This small, fragmented indigenous forest patch (approximately 1,000 ha) nests among Langeni pine plantations at an altitude of 1,600 meters above sea level (von Maltitz et al., 2003). The vegetation of the Transkei Afromontane forests is characterized by a multi-layered canopy comprising emergent trees, a tall, relatively open-to-closed upper canopy, and a dense understory with a well-developed herb layer (Gelderblom et al., 2003). The forests are underlain by mudstones, shales, and sandstones from the Balfour formation, with dolerite intrusions (Coleman, 1999).

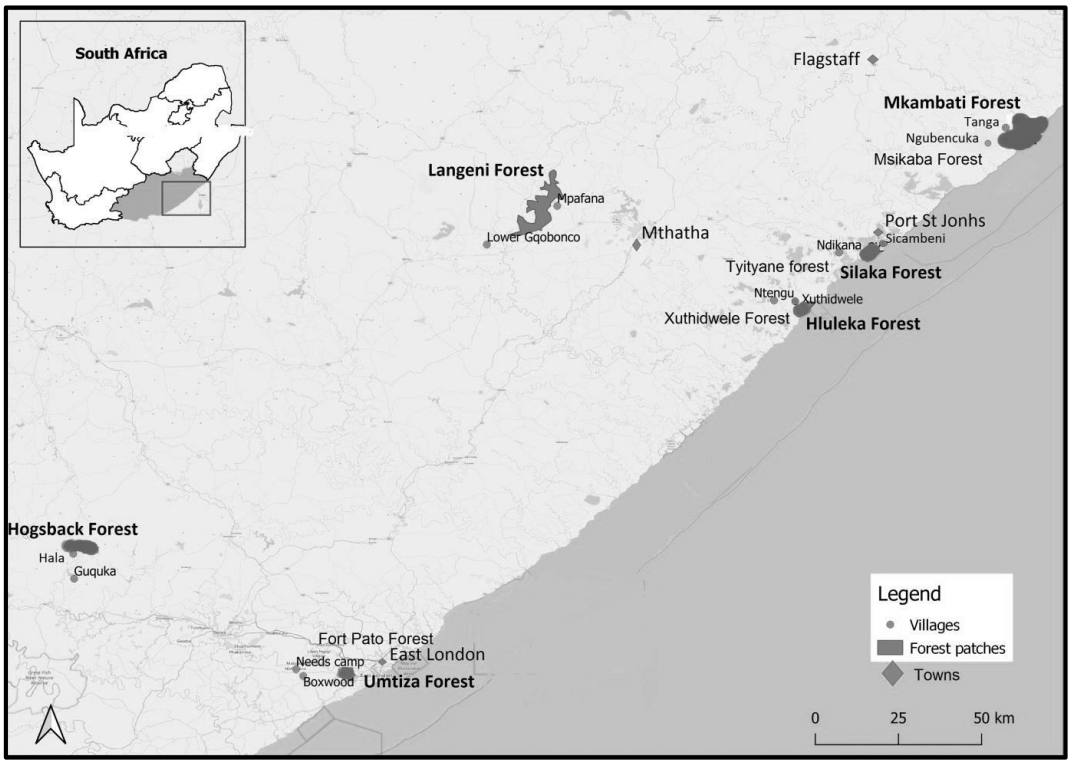

Figure 1.3: Map of the Eastern Cape showing the surveyed forests and adjacent villages.

The region experiences a temperate climate, with annual rainfall ranging from 800-1 800 mm, and seasonal temperature and rainfall patterns, including both summer and winter rainfall, with an average winter rainfall of 400 mm (Omar et al., 2016).

1.5.2 Characterization of Eastern Cape Coastal forests

Eight of the 12 forest patches in this study were situated within the Eastern Cape Coastal forests, a unique and biodiverse ecosystem that occupies a narrow strip along the Wild Coast of the former Transkei and the Indian Ocean seaboard (Mucina et al., 2020; Ehlers-Smith et al., 2017). This coastal forest strip is renowned for harboring a plethora of endemic species, (Martins et al., 2019). Furthermore, this region is also responsible for the isolation of populations of rare or tropical species found at the southern limit of their distribution, making it a critical area for conservation efforts (Gelderblom et al., 2003; von Maltitz et al., 2003).

The Umtiza and Fort Pato forests are small, similar forests, each approximately 500 ha in size, situated within the East London Coastal forests. These forests have a mild-to-warm and humid climate, bordering on subtropical, with a maximum altitude of 180 m (Mucina et al., 2020). The mean annual rainfall ranges from 800-1 000 mm, with most precipitation occurring during the spring and summer months (Ehlers-Smith et al., 2017). Annual temperatures fluctuate between 8-26°C, with a moderate temperature range (Omar et al., 2016). Geologically, the area is underlain by the Beaufort Group of the Karoo Supergroup, which comprises mudstones, shales, and sandstones (Coleman, 1999). The vegetation is characterized by tall canopy, with tree heights varying from 5 to 10 m in exposed areas and reaching up to 20 m in more sheltered locations (Gelderblom et al., 2003). Dominant canopy-forming tree species include *Ptaeroxylon obliquum*, *Buxus macowanii*, and *Harpephyllum caffrum* (von Maltitz et al., 2003). Understories are dominated by scrambled shrubs, creating dense and diverse habitats (Martins et al., 2019). Despite the local extinction of many large mammal species over the last century, these forests still support a range of mammal species, including sanango monkeys, blue duiker, common duiker, porcupines, giant golden moles, and tree dassies (Skinner and Chimimba, 2005).

The Hluleka and Silaka protected forests, along with the Xuthidwele and Tyityane communal forests, are situated within the Transkei Coastal forests. As shown in Figure 1.3, the Hluleka and Xuthidwele forests are located in the southern parts of the region, while the Silaka and Tyityane forests are found in the northern areas (Mucina et al., 2020). These forests are

characterized by low- to medium-crowned (9-25 m), species-rich canopies with poorly developed herbaceous layers. Typical canopy constituents include *Millettia grandis*, *M. sutherlandii*, *Buxus macowanii*, *Bauhinia natalensis*, and locally endemic *Umtiza listeriana* (Gelderblom et al., 2003). These forests occur on sloping coastal platforms and steep scarps in deeply incised valleys, ranging from sea level to 800 m above sea level (Ehlers-Smith et al., 2017). Nearshore proximity moderates the climate, resulting in a moderate, humid, and subtropical coastal climate. Summer temperatures range from 20°C to 25°C, while winter temperatures range from 8°C to 21°C (Omar et al., 2016). The region experiences high rainfall, with an average annual rainfall of 1 150 mm, with approximately 70% occurring between October and March and peaking in October and November (Mucina et al., 2020). Geologically, the Transkei Coastal forests are situated on an upstanding fault block of Table Mountain sandstone, surrounded by younger Ecca-age sediments, primarily shales (Coleman, 1999). The area is home to a diverse range of mammals, including vervet and sanango monkeys, blue duiker, common duiker, bushpig, bushbuck, monkey, and tree dassie (Skinner and Chimimba, 2005).

The Mkambati and Msikaba forests are situated within the Mpondoland Coastal forests, a unique and biodiverse ecosystem characterized by tall (15-25 m high), species-rich forests found on the Msikaba Formation sandstones of the coastal scarp ridge in northeastern Transkei and southern KwaZulu-Natal (Mucina et al., 2020). These forests exhibit structural diversity, with a poorly developed herb layer, and are typified by the wooded steep slopes of gorges, which contain numerous endemic species (Mucina & Rutherford, 2006). The distribution of these forests coincides with the Pondoland center of endemism identified by Van Wyk and Smith (2001), highlighting the importance of these forests in the conservation of regional biodiversity. The altitudinal range of these forests spans from sea level to 600 m, with proximity to the coast that influences their climate. These forests are characterized by strong north-easterly winds, cooler temperatures, and lower moisture levels than the eastern scarp forests to the north (Omar et al., 2016). The Pondoland scarp forests share biological similarities with the Transkei Coastal forests, highlighting their regional ecological importance.

The surveyed forests are largely surrounded by rural, impoverished communities that heavily rely on these forests for their daily livelihoods (Leaver & Cherry, 2020). The indigenous forests of the Eastern Cape are vital for the well-being of surrounding communities, providing edible resources, spiritual and esthetic needs, employment, and ecological services such as carbon

sequestration and water regulation (Sosibo et al., 2021). Furthermore, the forests serve various cultural and symbolic functions for local communities and are intimately linked to ancestry and cultural heritage (Cocks et al., 2011).

1.5.3 Socioeconomic information of the surveyed villages

As this is a social-ecological study, a significant part of the research was conducted with people from rural communities that live adjacent to the forests described above. For the social part of the study, I selected two villages related to each of the communal forests. Using Google Earth Pro (version 7.3) and ArcGIS v10.8.2 (ESRI, 2021), I selected the village closest to each forest because I anticipated that villagers would likely use the adjacent forest patch the most. Then, I randomly selected one village from among the villages in a 10 km buffer zone away from each of the forest patches. Thus, 12 villages were selected for the study (Figure 1.3).

In the Hogsback forest, Hala and Guquka villages were selected. According to Statistics SA (2011), Hogsback's population and surrounding villages is approximately 12 000 people, residing in around 2 500 households. The literacy rate in the area is around 80%, with a slightly higher rate among females (82%) than males (78%) (Stats SA, 2011). About 45% of the population lives below the poverty line, with a higher proportion of female-headed households experiencing poverty (48%) than male-headed households (42%) (World Bank, 2019). The gender ratio in the area is relatively balanced, with 51% of the population being female and 49% male (Stats SA, 2011). The employment rate in the area is around 55%, with a higher rate of employment among males (60%) than females (50%) (Stats SA, 2011). The dominant language spoken in the area is isiXhosa (80%), followed by English (15%) and Afrikaans (5%) (Stats SA, 2011).

In the area around Langeni Forest in Transkei Afromontane forests, I selected Mpafane Lower Gqobangco Village. The area is characterized by a predominantly rural socioeconomic landscape. According to a census 2010 conducted by Stats SA (2011), the population of Langeni and surrounding villages, such as Mpafane Lower Gqobangco, comprises approximately 25 000 people, residing in approximately 5,500 households. Stats SA (2011) further shows that the gender ratio in the area is relatively balanced, with 52% of the population being female and 48% male. The employment rate in the area is around 40%, with a higher rate of employment among males (50%) than females (30%) (Stats SA, 2011). The literacy rate in the area is around 70%, with a slightly higher rate among females (73%) than males (67%)

(Stats SA, 2011). The employment rate in the area is approximately 40%, with a higher rate of employment among males (50%) than females (30%) (Stats SA, 2011). Consequently, approximately 60% of the population lives below the poverty line, with a higher proportion of female-headed households experiencing poverty (65%) than male-headed households (55%) (World Bank, 2019).

According to the Nyandeni municipality IDP (2023), where Xuthidwele and Ntengu villages are located (adjacent to Hluleka forest), the population of the area is approximately 290,000, with approximately 63,000 households. The literacy rate is lower in the villages adjacent to Hluleka, including Xuthidwele and Ntengu, with around 60% of the population not having completed secondary education (Stats SA, 2011). The low literacy rates and the lack of education has resulted in significantly higher unemployment rates in these rural villages, with up to 70% of the population unemployed (Stats SA, 2011). Consequently, poverty rates are higher in these villages, with up to 70% of the population living below the poverty line (World Bank, 2019).

The rural villages around Silaka forest are also characterized by a predominantly rural socio-economic landscape. the population of these villages, including Sicimbeni and Ndikana, totals approximately 12,000 people, residing in around 2,500 households (Stats SA, 2011). The area has limited access to educational institutions and resources, which contributes to low literacy rates (Stats SA, 2011). Up to 70% of the population is unemployed, and up to 75% of the population lives below the poverty line (World Bank, 2019).

The rural villages surrounding Mkambati forest, including Tanga and Ngubencuka, face significant socio-economic challenges, including high poverty rates (75% of the population, low literacy rates (65%, limited access to education and employment opportunities, and low employment rates (35% (Stats SA, 2011). The dominant language spoken in the area is isiXhosa, which accounts for 95% of the population. These challenges are more pronounced among female-headed households, which experience higher poverty rates (80%) and lower employment rates (25%) than male-headed households (World Bank, 2019).

The villages around Umtiza and Fort Pato forests (Boxwood and Needs camp) exhibit a semi-rural socio-economic profile characterized by a population of approximately 8,000 individuals residing in 1,500 households (Stats SA, 2011). Literacy rates are modest at 60%, with a slight gender disparity favouring females (63%) over males (57%) (Stats SA, 2011). Compared to

the other villages in the study, these villages experience lower poverty rates, with just above 50% of the population living below the poverty line. The gender ratio is relatively balanced, with a slight preponderance of females (52%) over males (48%) (Stats SA, 2011). Employment rates are constrained at 30%, with males exhibiting a higher employment rate (40%) than females (20%) (Stats SA, 2011). As the villages are closer to East London, one of the economic hubs of the Eastern Cape, they experience fewer socioeconomic challenges than the other villages.

The rural communities situated in proximity to indigenous forests in the Eastern Cape rely heavily on forest resources to fulfill their livelihood requirements, owing to the prevalence of socioeconomic challenges such as elevated poverty rates, limited access to educational opportunities, and scarce employment prospects (Lindsey et al., 2013; Maroyi, 2022). To sustain themselves, these communities engage in a diverse array of livelihood strategies, including subsistence hunting, forest foraging, small-scale forestry, ecotourism, and the harvesting of non-timber forest products (NTFPs) such as brooms, thatching grass, and crafts (Shackleton and Shackleton, 2004; Maroyi, 2022). However, ensuring the long-term sustainability of these forest resources necessitates the implementation of sustainable forest management practices, which balance human livelihood needs with environmental conservation (Wiersum, 2004). Empowering local communities through capacity-building initiatives and clarifying tenure and resource rights can enhance livelihood benefits while promoting forest conservation and biodiversity (Shackleton et al., 2002; Maroyi, 2022). Furthermore, value addition to forest products through processing and marketing can augment income benefits for communities, thereby contributing to poverty alleviation and rural development (Maroyi, 2022).

1.6 Methods

The study adopted a mixed-methods approach. Mixed-methods research is defined as an approach that focuses on collecting, analysing, and mixing quantitative and qualitative data in a single study or series of studies (Stentz et al., 2012; Dawadi et al., 2021). Its central premise is that the use of quantitative and qualitative approaches in combination can provide a better understanding of research problems than either approach alone (Creswell et al., 2011). Mixed-methods research is becoming increasingly articulated and attached to research practice (Johnson et al., 2007; Schoonenboom et al., 2017). Mixed-methods approaches offer a comprehensive analysis of the overarching goal of the study (Stentz et al., 2012; Creswell,

2021). Mixed-method approaches are superior to single-method designs because they answer research questions that other methodologies cannot and enable stronger inferences and collating divergent views (Schoonenboom et al., 2017; Creswell, 2021; Dawadi et al., 2021).

Mixed-methods research is not new; it is a movement or research paradigm that has arisen in response to the limitations of quantitative and qualitative research (Johnson et al., 2007; Bergin, 2018). The most common and widely used types of mixed methods in research are convergent parallel, explanatory sequential, and exploratory sequential mixed methods (Creswell et al., 2011; Dawadi et al., 2021). For the purpose of this study, I employed an explanatory sequential design, which is a two-phase design in which quantitative data are collected first, followed by qualitative data (Figure 1.4) (Creswell et al., 2011). The core of this design is to use qualitative results to further explain and interpret findings from the quantitative phase.

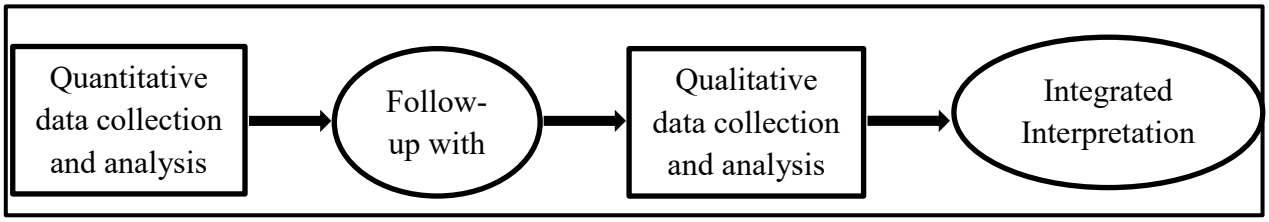

Figure 1.4: Explanatory sequential mixed-methods approach (Creswell et al., 2011)

The first phase of data collection involved household surveys and hunter interviews aimed at collecting data on bushmeat hunting and use. The household surveys and interviews were conducted via semi-structured, open-ended questionnaires that were administered by way of face-to-face interviews. This was then followed by quantitative data collection conducted in the form of ecological surveys that assessed the species diversity and densities of mammalian forest fauna and how bushmeat hunting affected these in the communal forests of the Eastern Cape province.

In each of the subsequent data chapters, a comprehensive and transparent account of the methodological approaches employed is provided, including a detailed description of data collection techniques, sampling design, and data analysis procedures.

1.7 Ethical considerations

All research involving animal or human subjects must undergo rigorous review by an independent committee to assess potential risks to both the subjects and researchers (Williams, 2001). This crucial step ensures that research is conducted ethically and responsibly. As the study was a social-ecological investigation involving household surveys and questionnaire

interviews with hunters, adherence to general ethical standards and those stipulated by the Rhodes University Ethics Committee was paramount.

To ensure compliance, the guiding framework provided by the Environmental Science Department under the authority of the Rhodes University Ethical Standards Policy and the Rhodes University Ethical Standards Committee Handbook was meticulously followed. This framework outlines the ethical principles and guidelines for research involving human subjects.

Before starting the study, a comprehensive proposal and questionnaires was presented and accepted in 2019, and ethical clearance was formally granted in April 2019 (Ethics No. 2019-1065-3178). This clearance confirms that the study's methodology and procedures meet the required ethical standards, ensuring the protection and well-being of all participants.

1.8 References

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CHAPTER 2

Use of Non-Timber Forest Products by rural communities in the Eastern Cape, South Africa: livelihood benefits associated with bushmeat hunting and use

2.1 Introduction

Over the past few decades there has been growing international appreciation of the importance of ecosystem services for rural communities in developing countries (Shackleton and de Vos, 2022). Non-timber forest products (NTFPs) are one of the primary services provided by ecosystems for marginalized populations (Zhu and Lo, 2021; Shackleton and De Vos, 2022). Globally, 3.5 billion people are partially or completely dependent on NTFPs for their daily livelihoods (Delgado et al., 2022). In most rural households NTFPs are used daily as an integral part of livelihoods (daily net) (Shackleton, 2015; Derebe and Alemu, 2023). In times of despair or adversity households may use NTFPs to mitigate temporary setbacks (Shackleton and De Vos, 2022). Regardless of the frequency of use, NTFPs are important to the survival of many rural households globally (Shackleton and Pullanikkatil, 2019).

NTFPs from wild animals are often important items for consumption and may also have spiritual and medicinal values in many human cultures (Nieman et al., 2019; Adebowale et al., 2024). Bushmeat is described as any wild, non-domesticated terrestrial mammal, reptile, bird, and amphibian harvested for human use (Van Vliet et al., 2015; Trefon, 2023). Bushmeat is deemed as one of the most important NTFPs as it offers several livelihood benefits for rural and urban populations globally (Mayor et al., 2022). Like many NTFPs, the hunting of bushmeat often serves both as the primary source of animal-based protein and a cash-earning commodity for many communities globally (Friant et al., 2020). Studies from the global tropics have shown that many people benefit from bushmeat; from those who consume it as part of a subsistence lifestyle, those who trade it at different stages of the supply chain, to urban consumers who eat it in their homes and restaurants (Rogan et al., 2018; Van Velden et al., 2020; Peros et al., 2021;).

The importance of bushmeat as a vital NTFP for rural communities has received worldwide appreciation (Van Velden et al., 2020). Bushmeat hunting has proved to be an essential source of protein and income for many impoverished forest-dwelling communities globally (Chapman and Peres, 2021). Many of these communities are faced with dire food insecurity (Torrez-Vitolas et al., 2019) and the hunting of wild animals provides the regular intake of protein to

enhance dietary and nutritional diversity (daily net) (Hoffman and Cawthorn, 2012; Fa et al., 2022). Bushmeat can also offer a 'safety net' function for rural households experiencing shocks such as natural hazards and health emergencies by providing nutritious resources and additional income through sale (Van Vliet et al., 2022).

Over 10 million tons of bushmeat is harvested from the global tropical forests annually (Chapman and Peres, 2021). This has seen over 300 mammalian species and subspecies threatened with extinction (Chapman and Peres, 2021); hence the so called 'bushmeat crisis' (Bennett et al., 2007). Despite the extensive evidence of excessive bushmeat harvesting, more than two decades later data on bushmeat hunting and use remains fragmented and incomplete, especially in drier biomes (Djagoun et al., 2022). More so, our knowledge of the complex socio-ecological relationships and cultural implications of bushmeat hunting remains limited (Torrez-Vitolas et al. 2019). Additionally, there is a large gap in knowledge on the household consumption of bushmeat as most studies focus on species conservation, harvest, and trade (Van Velden et al. 2018; Groom et al., 2023).

A review by Martins and Shackleton (2019) showed that only a handful of studies have assessed the prevalence of bushmeat harvesting to rural people in South Africa. These studies showed that 30-60% of households attested to consuming bushmeat to some extent. As subsistence hunting remains illegal in the country it is highly likely that these figures are underestimates. Hunting in South Africa, as in many parts of the continent, is gender differentiated, being done mostly by adolescent boys and young men (White, 2004; Kaschula and Shackleton, 2009; Grey-Ross et al., 2010). The motivations behind bushmeat hunting in South Africa seem to be largely a combination of culture and sport (White, 2004; Martins and Shackleton, 2019). However, several studies argue that subsistence hunting is crucial to the livelihoods of poverty-stricken people in biodiversity rich biomes (Hayward, 2009; Grey-Ross et al., 2010; Nieman et al., 2019). In the forests of the Eastern Cape, Hayward (2009) contended that poverty was the primary motivation behind bushmeat hunting; this is echoed by Grey-Ross et al. (2010) in KwaZulu-Natal. More recently, Nieman et al., (2019) found poverty as one of the drivers of hunting by people in the Western Cape. Contrary to this hypothesis, Manqele et al (2018) found no evidence that bushmeat was important to household livelihoods in rural KwaZulu-Natal. Others argue that hunting is done by both rich and poor households (White, 2004; Kaschula and Shackleton, 2009), thus indicating that poverty is not the primary

motivation for hunting in the sub-region. However, due to the limited research on subsistence bushmeat hunting in the country it is impossible to reconcile these two perspectives.

Bushmeat is listed as one of the most used NTFPs by rural communities globally (Abebe, 2020; Fromentin et al., 2023). There is increasing need to identify the contribution of bushmeat to rural households in the sub-Saharan region both from a conservation and developmental perspective. Studies on hunting in South Africa are mainly focused on the poaching of large charismatic species like rhinoceros; and commercial sport hunting on privately-owned game ranches (Martins and Shackleton, 2019). Martins and Shackleton (2019) further mention that in the sub-region researchers have largely overlooked hunting in communal lands for subsistence. Due to this, there is a dearth of knowledge on the prevalence and contribution of bushmeat to rural livelihoods. This is confirmed by the systematic review by Van Velden et al. (2018) that concluded that bushmeat hunting is understudied in southern Africa.

The aim of the current study is to evaluate the harvesting and use of NTFPs by rural communities surrounding forest patches in the Eastern Cape province, South Africa, and how bushmeat fits into the broader pattern of NTFP use. For this study bushmeat specifically refers to meat obtained from terrestrial forest mammal species and not introduced species like springbok, eland etc which are found in the protected areas. I further assess livelihood benefits associated with bushmeat hunting by investigating bushmeat hunting patterns and bushmeat consumption by rural households in the region. Numerous studies conducted in the rural settings of the province have highlighted the importance of NTFPs for these communities (Leaver et al., 2021; Chakona and Shackleton, 2019; Njwaxu and Shackleton 2019; Davenportet et al., 2012). Most of these studies show that all the rural households in the region make use of at least one NTFP daily. Though limited, research has also shown that bushmeat hunting occurs in the indigenous forests of the Eastern Cape and that the motivation for bushmeat hunting differs amongst the rural communities in the region (Sosibo et al., 2021; Grey-Ross et al., 2010; Kaschula and Shackleton, 2009; White, 2004). Based on this evidence I expect that the rural households in the region will harvest and use a variety of NTFPs with households harvesting different NTFPs at different frequencies. South Africa has a well-established social grant system and the rural communities in the region have access to a variety of animal-based protein sources; also, the forest biome is the smallest biome in the country hence harbouring fewer mammal species than the larger tropical forests. I hence further expect that compared to rural forest-dwelling communities in the global tropics, the contribution of bushmeat to livelihoods will be less prevalent in the Eastern Cape.

2.2 Methods

2.2.1 Study area

See Chapter 1

2.2.2 Site selection

See Chapter 1

2.2.3 Data collection

Using existing data on the number of households in each village from local municipalities and Google Earth Pro (version 7.3.0) all the households in each village were counted to achieve saturation, to ensure that the sample size is sufficient for the study. This was then followed by pilot visits in each of the villages. The pilot visits included visits to the chiefs or headmen of each village to discuss the proposed project and to gain permission to conduct research. Field assistants that were fluent in both isiXhosa and English were trained in conducting questionnaires and to be aware of evasion of answers. As the lead research was a Xhosa speaking male, the respondents were comfortable with sharing sensitive and potentially illegal information regarding bushmeat hunting with the researchers. Nevertheless, there is a possibility that some households or hunters might have been reticent to admit to engaging in hunting and hence the number should be viewed as minimum estimates.

A qualitative approach in the form of guided, semi-structured interviews was used to solicit data on the household use of NTFPs and the livelihood benefits associated bushmeat hunting and use. The thirty households in each village were selected randomly, giving each household in each village an equal chance of being selected. The questionnaire, comprised of both open- and closed-ended questions, was administered via face-to-face interviews with heads of households or an available adult (+18 years). The questionnaire interviews were conducted in 2020 from September to November.

Before commencing the interviews, it was clarified to respondents that, for the purposes of this study, bushmeat specifically refers to meat obtained from terrestrial forest mammal species and not introduced species like springbok, eland etc which are mostly in the protected areas.The questionnaires (Appendix 5) solicited data on extraction and use of NTFPs, bushmeat hunting, frequency of bushmeat consumption, general protein consumption, food security, natural

resource management institutions and the general demographics of each household. Each questionnaire took approximately one hour to complete. An informed consent letter was read, explained, and signed by each respondent prior to each interview and respondents were informed that they could stop the interview process at any point. The interview protocol was reviewed and approved by the ethics committee of Rhodes University (Ethics No. 2019-1065-3178). All of the interviews were conducted in isiXhosa and were translated to English later as the researcher is fluent in both languages. To explore emerging avenues of the discussion follow-up questions were asked during interviews.

Subsequently, snowball sampling was used to conduct interviews with hunting households to get further insights on bushmeat hunting and consumption. In each village, sample saturation was achieved (i.e., all the hunting households were interviewed). The number of interviews conducted using the snowball sampling method varied in each of the villages. A total of 486 random and snowball household interviews were conducted during the survey.

2.2.4 Data analysis

Data from the household questionnaires was entered into Microsoft Excel to allow for descriptive statistics to be calculated. The analysis of open-ended and close-ended questions followed a qualitative approach to capture the depth and nuance of respondents' perspectives. Responses were systematically coded into thematic categories. All statistical analyses were performed in R Environment version 4.1.3. To explore the relationship between a response variable and independent variables, multiple linear regression models (MLRM) were used. The consumption of bushmeat was the dependent variable (0 = never consumes and 1 = consumes) and the logistic regression and logit link function were used. Pearson’s chi-square test was used to test for household protein preference and the choice of protein source and frequency of bushmeat consumption compared to other protein sources.

2.3 Results

2.3.1 Household socio-demographic information

All the interviewed heads of households were above the age of 18 years, ranging from 32 to 86 years. The average age of the respondents was 53 ±12 years. Of the interviewed household heads 26% were females and 74% were males. Almost half, 43% reported primary school as

their highest level of education, 29% had a high school education below matric, 11% had completed matric, only 3% had a higher education and 15% were unschooled (Table 2.1).

The average household size and number of children under the age of 16 in the household were 6.4 ±2.63 and 3.0 ±1.85, respectively. Almost one-third (30%) reported to have some sort of employment; the rest (70%) stated that they were unemployed. On average 0.8 ±0.78 people were employed per household. All the households received some sort of government social grant.

Almost half of the households (44%) attested to keeping cattle, 46% had goats, 39% kept sheep, 49% had chickens and 59% cultivated field crops while 75% had garden crops (Figure 2.2). One-quarter (25%) of the interviewees mentioned that they had additional streams of income, ranging from selling produce from gardens, livestock and doing odd jobs within the village.

Table 2.1: Number of households interviewed and household information (Villages marked with * are the villages closer to the forest patches)

Site	**Villages**	**No. of households interviewed**	**Average age of HH heads**	**Average HH size**
Hogsback	Hala*	49	56.4±12.7	7.3±2.6
	Guquka	48	53.0±13.1	7.7±3.0
Langeni	Mpafane*	36	52.4±12.3	6.0±1.8
	Lower Gqobangco	37	51.0±11.6	6.0±3.0
East London	Boxwood*	40	51.3±12.0	4.9±1.6
	Needs camp	34	54.0±11.4	5.1±1.8
Hluleka	Xutidwele*	41	54.0±13.0	7.0±2.6
	Ntengu	38	51.0±11.0	5.4±1.8
Silaka	Sicimbeni*	44	51.0±12.1	7.1±3.0
	Ndikana	40	48.0±9.0	5.4±1.8
Mkambathi	Tanga*	44	56.0±14.0	6.0±2.4
	Ngubencuka	35	55.0±14.1	8.0±2.5
Total and mean (±SD)		**486**	**52.8±12.5**	**6.4 ±2.6**

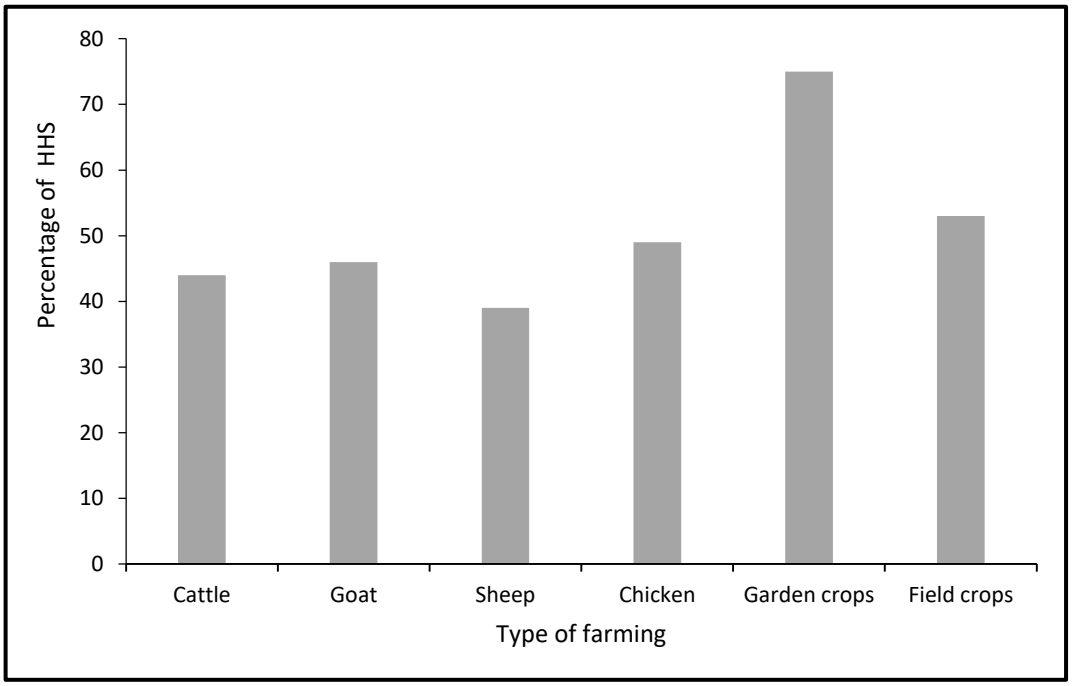

Figure 2.1: Percentage of farming practices by rural households in the sampled villages.

2.3.2 Household NTFP harvesting and use

All interviewees attested to harvesting NTFPs from the local forests, to be used within the household or sold in the nearest town or within the village (Table 2.1). Firewood was used by all the households, respondents stated that they preferred cooking with fuelwood as this was cheaper than electricity. Over 97% of households attested to using medicinal plants harvested from the local forests. The most used medicinal plant was the liquorice plant (*Helichrysum petiolare*), believed to summon and calm ancestors and also drive away malicious or evil spirits. The gathering of poles from local forests for fencing, making livestock kraals and residential construction was common (95% of households). Almost 80% of households had wooden utensils which were either made by a family member or bought from a local vendor. These included fighting sticks, wooden spoons, axe handles and other tools which were used around the households. Indigenous wild plants and fruits were used by over 80% of the households.

Over 60% of households had products made from reeds. These were predominantly sleeping mats, each household had about 4 - 5 of these in various sizes. Other items included baskets, small mats and trays. Thatch grass was collected by 60% of households, all these households had one or more thatched structures which needed regular maintenance. Fish was mostly consumed by households in villages around the Coastal forests, 60% of households attested to

regularly consuming fish which was either bought from local fishermen or caught by a member of the household. More than 50% of the households attested to harvesting bushmeat from local forests. Shellfish was used by 26% of households including mussels and abalone.

Table 2.2: Non-timber forest products harvested by rural households in the sampled villages (in descending order)

Non-timber forest products harvested	Total number of households using	% of households using
Firewood	486	100
Medicinal plants	475	97.7
Poles	463	95.3
Wood (for utensils)	386	79.4
Wild vegetables	372	76.5
Wild fruits	322	66.3
Reeds	304	63.6
Grass (for thatching)	292	60.0
Fish	286	58.8
Bushmeat	253	52.1
Shellfish	124	25.5

Figure 2.2 shows the frequency of NTFP harvesting by households in the surveyed villages. Most (73%) of the households in the study area harvested firewood weekly; whilst 43% of households attested to harvesting medicinal plants irregularly. The harvesting of poles for construction, wood for utensils, reeds and grass for thatching was mainly a rare practise; these were harvested when they were needed. The harvesting of wild vegetables and fruits was mostly done weekly by the households on the study area. The majority (44%) of the households that harvested fish mentioned that they did so weekly; whilst bushmeat was mainly harvested monthly. Shellfish was the least harvested NTFP, usually collected monthly.

In the study area most (94%) of the household heads mentioned that the use of NTFPs has increased in the respective villages due to unemployment and the recent Covid-19 pandemic. All the interviewees stated that there was a decline in the availability of NTFPs in the nearest forests, most attesting to illegally harvesting in protected areas or having to travel long distances and spending more time in the forest searching for NTFPs.

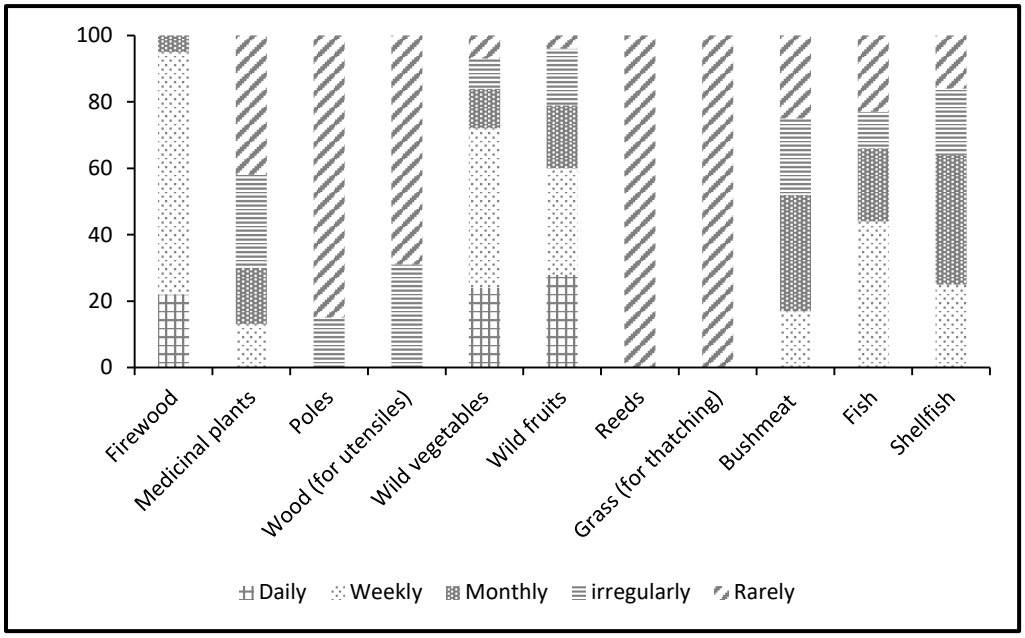

Figure 2.2: Frequency of NTFP harvesting by households in the surveyed villages.

2.3.3 Household bushmeat hunting patterns

The villages in the study had a total of 1 615 households (Table 2.3). Of the total 360 random households surveyed, 127 attested to hunting in the past year. Subsequently, this was followed by the snowball sampling method which further revealed a further 126 hunting households (i.e. all hunting households recommended were interviewed), making the total of 253 (16%) households that attested to hunting in the past 12 months in the study area. Hala village in Hogsback had the most hunting households (30); with Needs camp in East London having the least no. of households (11) that hunted in the last 12 months.

As shown in table 2.3, villages closer to forest patches had more hunting households than villages further away from forest patches. The respondents stated that hunting was conducted by themselves or by young men and boys. In female-headed households, it was mentioned that their sons or other males in the household engaged in bushmeat hunting.

Table 2.3: Percentage and number of households that attested to hunting in the last 12 months (Villages marked with * are the villages closer to the forest patches)

Site	Villages	No. of HH in village	No. of HH hunting	% of HH hunting
Hogsback	Hala*	158	30	19
	Guquka	94	27	29
Langeni	Mpafane*	186	18	10
	Lower Gobangco	107	17	16
East London	Boxwood*	124	14	11
	Needs camp	116	11	10
Hluleka	Xutidwele*	148	24	16
	Ntengu	109	21	19
Silaka	Sicimbeni*	97	26	27
	Ndikana	136	25	18
Mkambati	Tanga*	169	26	15
	Ngubencuka	171	14	8
Total		**1 615**	**253**	**16**

The results of the multiple linear regression model fitted on household hunts against different household attributes presented in Table 2.4 showed an overall significant, albeit weak relationship (r^2 = 0.035; df = 476; F = 2.96; p = 0.002). There was a significant positive correlation between household bushmeat hunting and household farming ($p < 0.05$), suggesting that in the area farming households did the most hunting. The results further showed a significant negative relationship between household bushmeat hunting and the head of household receiving a government social grant, implying that households are most likely to hunt if the head of the household does not receive a social grant. There was no significant correlation between households engaging in bushmeat hunting and other household attributes ($p > 0.05$).

Table 2.4: Results of multiple linear regression model fitted on if household hunts against different household predictor variables.

Attributes	estimate	std, error	r^2-value	p-value
Age	0.004	0.003	1.293	0.20
Education	0.003	0.025	0.110	0.91
Household size	-0.008	0.014	-0.550	0.58
No. of children	-0.026	0.037	-0.692	0.49
Head of HH employed	-0.031	0.053	0.594	0.55
No. of employed in HH	0.028	0.031	0.909	0.36
Head of HH receives social grant	**-0.176**	**0.084**	**-2.089**	**0.04**
No. of social grants in HH	0.008	0.036	0.208	0.84
HH farms	**0.206**	**0.054**	**3.826**	**0.0001**

Seventeen percent of the households hunted on a weekly basis, whilst 35% revealed that hunting was conducted monthly. A further 23% households mentioned that hunting was an infrequent activity done occasionally by the head of the household and his sons or other members of the family. The remaining 25% households stated that hunting was a rare practice done by a visiting family member or by young men in the household.

2.3.4 Household bushmeat consumption

Bushmeat was consumed in 64% of the households in the 12 months prior to the study. Twelve percent of respondents mentioned that the hunter in the household brought their catch home and consumed the meat with their families and neighbours, whilst 36% said they consume their catch with other hunters and only shared the meat with children (mostly young boys). The remaining 16%, who were mostly elderly men, mentioned that they obtained bushmeat from neighbours, family members or bought it from local hunters. Since there is no bushmeat market where bushmeat was sold openly, bushmeat is sold at social grant pay points or orders are made with known hunters.

Reasons for bushmeat consumption were consistent across the interviewees, all mentioning that they preferred the taste and that it was healthier than other animal-based protein sources. A handful of the respondents mentioned that wild meat was an aphrodisiac and enhanced their sexual performance. All the female respondents did not particularly prefer bushmeat over other animal-based protein sources, stating that it was dirty meat, tough, and had no fat.

Respondents tended to prefer chicken as their first choice of protein, followed by beef then bushmeat (Table 2.6). Whilst fish, mutton and pork were not preferred as the first choice of protein by any of the respondents. Mutton was the least preferred protein source. Other protein sources consumed by the household in the study area included beans, eggs, and milk. Different protein sources were consumed at different frequencies by each household as shown in Figure 2.3. Eggs and milk were consumed daily by 125 (26%) and 135 (28%) households, respectively, none of the households mentioned they consumed any other protein source daily. All the protein sources, except for lamb were consumed weekly by one or more households. Most households in the area consumed beans, chicken and eggs weekly, whilst beef was mostly consumed monthly. Bushmeat was consumed in all the frequency categories except daily.

Table 2.6: Animal-based protein sources and the total number of households who preferred the protein.

Choice	Bushmeat	Beef	Chicken	Lamb	Pork	Mutton	Fish
1st	115	153	208	10	0	0	0
2nd	12	273	43	124	18	0	16
3rd	0	44	86	254	20	0	43
4th	1	16	58	87	62	74	189
5th	10	0	78	0	24	311	63

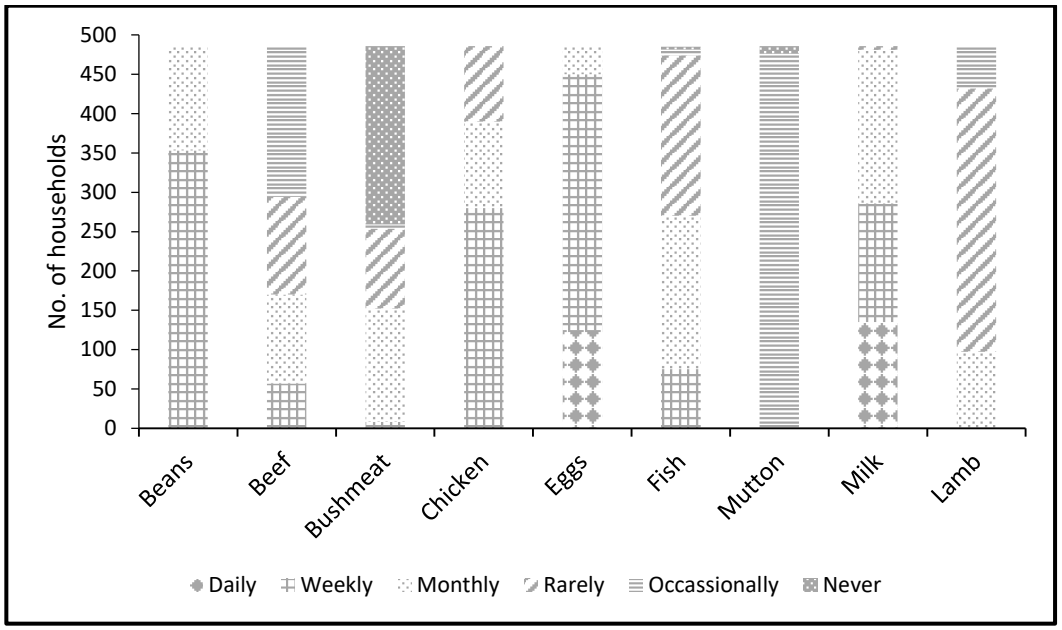

Figure 2.3: The frequency of protein consumption by rural household in the sampled villages

Ten forest mammal species were consumed as bushmeat. There was no significant association between species consumed and the frequency of bushmeat consumption ($\chi^2 = 20.59$; $df = 21$; $p = 0.48$). Bushbuck (*Tragelaphus scriptus*) was the most consumed species, followed by duiker spp. and bushpig (*Potamochoerus porcus*). Other forest mammals consumed included Cape porcupine (*Hystrix africaeaustralis*), mongoose spp, Vervet monkey *(Cercopithecus aethiops*), and rodents. The blue duiker (*Philantomba monticola*) is listed as vulnerable whilst the Samango monkey (*Cercopithecus labiatus*) is listed as endangered in the country.

2.4 Discussion

2.4.1 NTFP use by rural households in the sampled villages

Non-timber forest products play an important role in the sustainability and subsistence of rural communities in South Africa (Njwaxu and Shackleton, 2019). The role of NTFPs as a

livelihood strategy for rural households in the country has been highlighted by numerous researchers (Shackleton and Shackleton, 2004; Pandey et al., 2016; Mugido and Shackleton, 2019; Martins and Shackleton 2022). Rural communities in South Africa extract a variety of NTFPs from local forests mostly for household use (Leaver and Cherry, 2020); numerous studies have also shown that these forest products can be traded for financial income (Mugido and Shackleton, 2019; Sardeshpande and Shackleton, 2020; Shackleton, 2021). The harvesting and use of NTFPs differs, households may use NTFPs as a daily net (Mudigo and Shackleton, 2019); or as safety or emergency nets in times of adversity and hardship (Shackleton et al., 2011; Shackleton et al., 2024).

My results confirmed the importance of NTFPs for rural households throughout the sampled villages in the Eastern Cape. The most widely used NTFPs were firewood, medical plants, poles for construction, wood for utensils and wild fruits. More than half of the surveyed households also made use of reeds, grass for thatching and bushmeat. The findings from the study are largely aligned with studies conducted in the region, confirming that NTFPs are essential for the livelihoods of rural communities in the province (Davenport et al., 2012; Shackleton, 2013; Sosibo et al., 2022). In the past few decades, the country experienced increased unemployment and loss of jobs (Kambule, 2020). During the survey of rural villages of the Eastern Cape, the interviewees attested to an increase in NTFPs harvesting and use due to unemployment. These findings confirm the results from Paumgarten and Shackleton (2011) who reported an increase in NTFP use in times of adversity. Furthermore, the interviewees revealed that there was a decline in NTFPs availability due to different anthropogenic pressures. They stated deforestation, over-harvesting, cultivation; and commercial harvesting as the main reasons for the decline in the availability of NTFPs.

The use of NTFPs was a widespread feature throughout the sampled villages as all the households used at least one NTFP agreeing with the findings of Maroyi (2017) who also reported that all rural Eastern Cape households used a minimum of one NTFP. A total of 11 NTFPs were used in the study area, with firewood being used by all the households. Though all the households in the study were connected to the national electricity grid, they all stated that they preferred to use firewood for heating their households and to cook as this was cheaper, and the food was tastier. Medicinal plants, poles (for construction), wood (for utensils) and wild vegetables were used by more than 70% of the households.

Most of the surveyed households attested to harvesting fuelwood, wild vegetables, wild fruits and fish on a weekly basis. Fuelwood and wild fruits were also collected by young girls and boys daily on their way back from school. Contrary to studies conducted in West and Central Africa (Kümpel et al., 2010) where the harvesting of bushmeat was a daily practice, bushmeat and shellfish were mostly harvested monthly. Other NTFPs including poles (for construction), reeds and grass (for thatching) were harvested when they were needed by households.

As hypothesised, and echoing multiple studies conducted in the region, NTFPs are important to rural livelihoods in the area (Mtati, 2014; Roland and Oyelana, 2014; Sosibo et al., 2022; Mjoli and Shackleton, 2024). The results confirm that in rural settings households make use of one or more NTFPs to meet their livelihood needs. Furthermore, NTFPs are used both to meet household daily needs and as a safety or security net, in times of hardship.

2.4.2 Household bushmeat hunting patterns

In the household survey, 16% of the households attested to bushmeat hunting. Similar to the findings of Rogan et al. (2018) who assessed household bushmeat hunting in the Okavango Delta in Botswana and found that 18% of the households attested to hunting. These findings strongly contrast with results from studies conducted in tropical forests where bushmeat is the mainstay of rural diets as many households depend on bushmeat for their protein needs (Fa et al., 2022). In Central and West Africa bushmeat accounts for more than 80% of the protein intake of both rural and urban households (Cawthorn and Hoffman, 2015; Brittain et al., 2022; Trefon, 2023). In the global tropics bushmeat is a vital contribution to the food security, nutrition, and well-being of forest-dwelling communities (Nasi and Fa, 2015; Koné et al., 2023). In the rural villages of the Eastern Cape province, there was a strong correlation between household farming and bushmeat hunting, showing that farming households are more likely to engage in bushmeat hunting. This was also the case in Botswana where bushmeat hunting was twice as common in farming households as in non-farming households (Rogan et al. 2018).

Household bushmeat hunting is not well documented in southern Africa, as research efforts are mainly focused on legally permitted hunting within designated areas and the impact of hunting on wildlife in fenced game reserves (Martins and Shackleton, 2019). In all the surveyed villages, the village closest to the forest patch had more hunting households compared to the villages further away from the forest. Yet, whether the proximity of villages to a forest patch had an influence on household bushmeat hunting was tested, and there was no significant

difference in four of the six study sites. These results are echoed by Van Velden et al. (2020) who assessed bushmeat hunting amongst rural communities in the African savannah and mentioned that villages closer to park boundaries had more hunters compared to villages further away from parks.

The interviewees revealed that hunting was conducted by young to middle-aged men who were mostly unemployed and that bushmeat hunting was not important to the overall household livelihood. Unlike in West and Central Africa where bushmeat is used for direct household provisioning and income generation (Kümpel et al., 2010; Jones et al., 2029; Mavah et al., 2022). For many rural households in Central and West Africa bushmeat hunting is not a matter of choice but is necessary for the survival of the household (Van Velden et al., 2020; Trefon, 2023); as many of these households are without an income or any other protein alternatives.

In South Africa, government social grants are provided to assist local livelihoods. Grants are given to South African citizens who are vulnerable to poverty and in need of government assistance (Chakona and Shackleton, 2019). These mostly include older people, people with disabilities, and people with young children. All the households in the study received some sort of government social grant, the average number of social grant recipients per household was 3.1 (± 2.1). There was a negative significant relationship between hunting households and households where the head received a social grant. This indicates that if the household head receives a social grant there is a lower probability that the household hunts. Several studies have shown that even though some households may hunt because of lack of alternative food/protein sources, some households hunt as it is part of their culture and it has been in their family for generations (Van Vliet and Mbazza, 2011; Friant et al., 2015; Van Vliet, 2018; Foya et al., 2023). In the current study none of the participants attested to hunting bushmeat because of they lacked an alternative source of protein, but rather they hunted because they wanted to as it was part of their culture, or they preferred the taste of the meat. Some young men mentioned that hunting is a recreational activity and was something they learned from their fathers and uncles, some mentioned that bushmeat was an aphrodisiac and enhanced their sexual performance.

My findings revealed that in 12% of the hunting households, the hunter bought the catch home for consumption by the entire family. At most, the prey was consumed with other hunters, and with men and boys in the household. Almost half (46%) of the hunting households were female-headed households, yet only 13% of the female heads consumed bushmeat.

2.4.3 Household bushmeat consumption

The results of the survey on household bushmeat consumption by rural households near indigenous forest patches in the Eastern Cape province revealed that 64% of households attested to consuming bushmeat in the last 12 months. Bushmeat was predominately consumed by men and boys in the households; many females did not particularly enjoy the taste of the meat stating that it was dirty meat and was very tough. These results concur with the findings of White (2004) who found that bushmeat consumption in rural Eastern Cape was mostly by adolescent boy and young men. These results contradict the findings of numerous studies that assessed household bushmeat consumption in the tropical regions where bushmeat is reported as the primary source of household protein and is consumed by all members of the household (Mbete et al., 2011; Ordaz-Nemeth et al., 2017; Friant et al., 2020; Van Vliet et al., 2022).

Given the illegal nature of bushmeat hunting in the country any trade of bushmeat is a private and discrete practice. Sixteen percent of the interviewees mentioned that they bought bushmeat from local hunters, these were elderly men who used to be hunters but could no longer hunt due to old age. The men mentioned that they ordered bushmeat from local hunters stating which species they preferred or bought bushmeat at social grant pay points. None of the interviewees attested to a local or urban market where street vendors traded bushmeat openly. These results contradict the findings of studies conducted in other parts of Africa where street vendors sell bushmeat in local and urban bushmeat markets (Mc Namara et al., 2015; Luiselli et al., 2020; Peros et al., 2022). In Guinea, West Africa, Dounamou et al. (2021) recorded a total of 1 162 carcasses from 42 species traded by vendors in the bushmeat market in the area. Whilst in the Democratic Republic of Congo, Batumike et al. (2021) mentioned that 11 species were sold by the vendors in the market. The street vendors in the region preferred to sell smoked carcasses as they were easier to preserve. In the survey of household bushmeat consumption in the Eastern Cape, bushmeat was brought by the hunter in the household, purchased from local hunters or was a gift from extended family or neighbours.

In the region, 23% of the participants mentioned that they preferred bushmeat as their primary source of animal-based protein. All the participants who preferred bushmeat as their first choice of protein were men. Forty-three percent of the interviewees preferred chicken as their first choice of animal-based protein and 31% stated beef as their first choice. Unlike in the tropical regions where bushmeat is the most available and affordable animal-based protein source (Friant et al., 2019; Fa et al., 2015; Ziegler et al., 2010); different sources of animal-based

protein are available in the region, with more than half (56%) of the surveyed households keeping some sort of livestock and fish harvested on a weekly basis by more than 40% of the households.

The frequency of bushmeat consumption largely depended on the availability of bushmeat. Thirty-four percent of the interviewees attested to consuming bushmeat monthly, whilst 24% attested to rarely consuming bushmeat, few households consumed bushmeat weekly and occasionally, none of the households consumed bushmeat daily. Yet in Central Africa Van Vliet and Mbazza (2011) found that both rural and urban households consumed bushmeat almost daily as this was the cheapest or the only form of animal protein available. In the Central African Republic, Fargeot et al. (2017) reported an increase in bushmeat consumption in the rainy season, with households consuming almost double the amount compared to the dry season.

Ten forest mammal species were reported to have been consumed by the interviewees in the household surveys. Bushbuck (*Tragelaphus scriptus*) was the most consumed followed by duiker spp. and bushpig. Other species consumed included mongoose spp., hyrax spp., cape porcupine (*Hystrix africaeaustralis*), vervet monkey (*Cercopithecus aethiops*), and rodent species. and African wild cat (*Felis lybica*). These findings confirm the results of Hayward (2007) who assessed bushmeat hunting in the same region and reported that ungulates were the most targeted species. In the bushmeat markets of Ghana, the most traded species were rodents, ungulates and primates, consumers also purchased tree hyrax (*Dendrohyrax dorsalis*), reptiles and pangolins (Sackey et al. 2022).

2.4.4 Conclusions and recommendations

The use of NTFPs was an important part of the livelihoods of the interviewed households in the study. This confirms literature on the use of the NTFPs by rural communities in the region. All the households in the study made use of NTFPs collected from local forests and the interviewees all agreed that they would not be able to survive without NTFPs as these were free resources that were important for their daily subsistence. NTFPs continue to be an integral part of rural livelihoods throughout the Eastern Cape as they play different roles in different households. Most of the interviewed households use NTFPs as a ‘daily net’ to meet the household’s daily subsistence needs. Some households used certain NTFPs as safety or emergency nets in times of dire adversity.

The study's findings indicate that bushmeat utilization as an NTFP in the research area is predominantly a culturally driven practice, exhibiting pronounced gender specificity, with a minority of females engaging in consumption and appreciation. Contrasting with tropical regions where bushmeat is a vital component of local livelihoods, the study area's households do not rely heavily on bushmeat as a primary protein source or significant income generator. Instead, household consumption is largely contingent upon the presence of a male hunter, with most hunter-less households abstaining from bushmeat consumption. Notably, bushmeat plays a peripheral role in rural livelihoods, as the harvested prey is predominantly consumed by hunters and their male peers, rather than being integrated into household food systems, underscoring the need for nuanced understandings of bushmeat's role in different socio-ecological contexts.

This study provides valuable insights into the contribution of bushmeat at the household level in South Africa, but its short-term scope and regional focus necessitate further comprehensive assessments to elucidate the nationwide significance of bushmeat in rural communities. Future research should prioritize nationwide surveys, longitudinal studies, multi-disciplinary approaches, and policy-relevant findings to capture the diversity of bushmeat use patterns, account for seasonal and annual fluctuations, and inform conservation and development policies that support sustainable use of bushmeat resources, ultimately ensuring effective management strategies that benefit rural livelihoods and conservation.

Future research should employ longitudinal and cross-regional studies to assess temporal and spatial variations in bushmeat use, particularly in response to economic and environmental shifts. Ethnographic and participatory approaches can uncover the cultural significance of hunting**,** including its role in identity, knowledge transfer, and conservation perceptions. Policy-focused research should evaluate existing regulations and explore how customary governance can support sustainable management. A transdisciplinary approach integrating ecology, anthropology, and policy analysis is essential for developing context-specific strategies that balance biodiversity conservation with rural livelihoods.

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CHAPTER 3

Bushmeat hunting practices by rural communities in the Eastern Cape: motivations, methods, and perceptions

Picture of hunting dogs in a rural village in the Eastern Cape (Picture taken by researcher)

3.1 Introduction

Bushmeat hunting is defined as the human practice of pursuing and capturing or killing wild vertebrates, including terrestrial mammals, reptiles, amphibians or birds (Van Velden et al., 2020). The most common motives for humans to hunt wild animals are for meat and other useful animal products (e.g. fur/hide, tusks, horns/antlers) (Van Vliet and Mbazza, 2011). For millennia, rural people around the world hunted wildlife without grievously affecting animal populations (Antunes et al., 2019) and thus wild animals became an important dimension of human culture and evolutionary history (Van Velden et al., 2020). Hunters from rural settings engage in bushmeat hunting for various reasons. Subsistence hunters hunt to fulfil their and their family's protein needs, and sporadically the needs of the entire community (Batumike et al., 2021). Hunting can also be for recreational purposes where hunting is for entertainment and pleasure rather than food (Minin et al., 2021), or sporting reasons, where hunters and their hunting dogs compete based on skill, speed, endurance, and efficiency in catching prey (Minin et al., 2021). At times this may include monetary bets, prizes, or recognition based on performance. Whilst some may hunt for commercial purposes, trading their catch for financial gain (Bachmann et al., 2019). In many regions, culture is also a key reason for bushmeat hunting (Morsello et al., 2015; Van Vliet et al., 2015; Van Vliet 2018; Van Velden et al., 2020).

For the past two decades, there has been a growing body of research examining the primary motivations behind bushmeat hunting (e.g. Ashayeri and Newing, 2012; Nuno et al., 2013; Nielsen and Meilby, 2015; Van Velden et al., 2020). This literature shows bushmeat hunting to be influenced by many social, economic, and environmental factors (Ripple et al., 2016; Torres et al., 2021). Proximity to wildlife areas plays a significant role in the hunting patterns and practices (Hove et al., 2013) as the length of the travel time and from hunting areas affects both frequency of hunting and the practices adopted (Brodie and Fragoso, (2021). Additionally, most of the regions where bushmeat is harvested are faced with economic challenges due to expanding human populations, limited revenue streams, and lack of employment opportunities (Hove et al., 2013). For rural communities in such regions, bushmeat may serve as a vital source of protein and income as they are faced with limited or no alternatives (Torres et al., 2021). The vast majority of studies from the tropical forests of Africa suggest that trade is the main motivation for bushmeat hunting (e.g., Bowen-Jones et al., 2003; Cowlishaw et al., 2005; Lindsey et al.,2011; Nyaki et al., 2014). In contrast, in the limited research in subtropical forests, various motivations of bushmeat hunting have been documented, including poverty, culture, recreation, and income (White, 2004; Hayward, 2009; Shackleton et al., 2007; Kaschula and Shackleton, 2012; Manqele et al., 2018; Van Velden et al., 2018; Young et al., 2018; Nieman et al., 2019; Sosibo et al., 2022). Similarly, the bushmeat market in most South American countries, besides those in the Amazon basin, is considered insignificant as alternative animal protein sources are readily available (Van Vliet et al., 2017; Nielsen et al., 2017; Aragão Silva et al., 2023). But in the Amazon basin almost half of urban households consumed bushmeat at least once a month, mostly for cultural and taste preferences (Parry et al., 2014).

In many places, bushmeat is harvested at unsustainable rates. Estimates of extraction rates range from 10 to 20 million metric tons of bushmeat harvested from African tropical forests per annum, with more than 60% of large mammal species harvested at unsustainable rates (Fa et al., 2002; Brashares et al., 2004; Cowlishaw et al., 2005; Brodie and Gibbs, 2009; Van Vliet et al., 2011). In southern Africa, Lindsey et al. (2013) mention that over 50 000 tons of bushmeat are sold (illegally) in Zimbabwe and over 200 000 tons is sold in Mozambique annually. Due to the illicit nature of the business, it is difficult to determine the exact amount of bushmeat traded globally (Van Velden et al., 2018). However, harvesting rates are increasing as hunters access forests that were previously inaccessible, due to the development of roads and rail networks by logging and mining companies (Wilcox and Nambu, 2007). The

improvements in weapons technology have also contributed to the so called 'bushmeat crisis' as hunters have shifted from traditional methods of hunting (e.g., bow and arrow) to modern techniques like guns and wire snares (Braga-Pereira et al., 2020).

In most countries the hunting of wildlife is regulated through legislation (Lindsey et al., 2011). Permit systems specify restrictions on times and places that hunting is permitted, the species or number that may be hunted and the hunting methods that may be employed (Van Vliet et al., 2019). Van Vliet et al. (2019) further state that in many rural settings, bushmeat hunting violates such restrictions as hunting often takes place at any time and any species is harvested. Subsistence and commercial hunters from rural settings employ a variety of hunting methods to capture different species (Gill et al., 2012). Snares are the most common hunting method as they are an inexpensive and efficient method (Knapp, 2012). However, due to their low value some hunters may check snares infrequently causing wildlife wastage as trapped animals may be in snares for days leading to decay (Lindsey et al., 2013). Snares are particularly undesirable from a conservation viewpoint as they are largely unselective in terms of species and gender of animals captured, they are difficult to detect and still kill the animal whether checked or not (Lindsey et al., 2015). Alternatively, dogs are often used by subsistence hunters to flush wildlife or chase animals into holes, where they are dispatched with spears, sticks or bows and arrows (Jachmann, 2008; Grey-Ross et al., 2010; Lindsey et al., 2015). The use of firearms has been recorded in several settings; these include single-shot, shotguns, and home-made rifles (Lindsey et al., 2015). In South Africa, Hayward (2009) reported that hunters used a mix of snares, guns, dogs and sticks (Hayward, 2009).

In southern Africa specifically, bushmeat is an important natural resource for rural communities (Van Velden et al., 2018; Rogan et al., 2018; Martins and Shackleton, 2019). Protein from wild animals serves as a supplement to household diets and livelihoods of many communities in the region (Kaschula and Shackleton, 2012; Martins and Shackleton, 2019). Though there is very limited knowledge on the extent of bushmeat use in South Africa, the few studies conducted show that the hunting of wild meat for subsistence, cultural and traditional purposes is widespread (White, 2004; Hayward, 2009; Shackleton et al., 2007; Kaschula and Shackleton, 2012; Manqele et al., 2018; Van Velden et al., 2018; Young et al., 2018; Martins and Shackleton, 2019; Nieman et al., 2019; Sosibo et al., 2022). In the forests of the Eastern Cape province, Shackleton et al. (2007) revealed that eleven different faunal species were hunted and consumed, with bushbuck (*Tragelaphus scriptus*), bushpig (*Potamochoerus pocus*),

vervet monkey (*Cercopithecus aethiops*) and common duiker (*Sylvicapra grimmia*) being the most widely consumed. White (2004) reported that scrub hare (*Lepus saxatilis*), large grey mongoose (*Herpestes ichneumon*), water mongoose (*Atilax paludinosus*) and large-spotted genet (*Genetta tigrina*) were also consumed.

Understanding bushmeat hunting necessitates a holistic perspective that acknowledges its embedding within complex social-ecological systems (SES), where reciprocal interactions between human and natural components yield multifaceted outcomes, influenced by various feedback loops and external drivers (Preiser et al., 2018; Van Vliet et al., 2015; Van Vliet & Nasi, 2015; Fromentin et al., 2022). A nuanced approach must consider the interplay between the hunting terrain, stakeholder dynamics, ecological processes, and diverse external factors shaping the hunting practice (Fromentin et al., 2022). By conceptualizing bushmeat hunting as a complex, adaptive SES, researchers can systematically integrate social, economic, and environmental variables, fostering a deeper comprehension of the intricate relationships and emergent outcomes within the system (Froese et al., 2022), ultimately informing effective management strategies that balance human needs with environmental sustainability (Froese et al., 2023).

Studies assessing bushmeat hunting practices in South Africa remain limited. In a literature review of such, Martins and Shackleton (2019) showed that only a handful of studies have assessed bushmeat hunting in-depth, leaving many gaps in knowledge about the motivations, methods, perceptions and impacts of bushmeat hunting in the sub-region. Consequently, there is insufficient knowledge on which to design and implement bushmeat hunting policies and strategies. Therefore, the aim of this study was to provide a detailed analysis of bushmeat hunting practices by rural, subsistence hunters in the Eastern Cape province of South Africa. I sought to understand the motivations behind the hunting of bushmeat in the region, the methods hunters use and how hunters perceive hunting and the forests. Given that proximity to forests plays a role in bushmeat hunting (Van Velden et al., 2020; Torres et al., 2021), I assessed the differences in hunting practises by hunters from villages close to forests patches to those in villages further away from forest patches. I hypothesised that (i) bushmeat hunters would be present in all the surveyed villages; with villages closer to forest patches having more hunters, (ii) the motivations behind bushmeat hunting would be diverse, and the methods employed by hunters would be determined by their motivation to hunt, and (iii) hunters from villages close

to forest patches will hunt more and use different methods to those of hunters from villages further away.

3.2 Methods

3.2.1 Study area

See Chapter 1

3.2.2 Site selection

See Chapter 1

3.2.3 Data collection

Pilot visits to each of the 12 villages were conducted. The pilot phase included visits to the village chief or headmen to discuss the proposed project, to gain permission to conduct the research and identify hunters (resource users) in each village. A quantitative approach in the form of guided, semi-structured interviews was used to solicit data on bushmeat hunting practices amongst the hunters in each village. Field assistants were trained in conducting questionnaires and to be aware of evasive answers. As the lead researcher is a Xhosa speaking male the hunters in each village were inclined to share in-depth views on their motivations, methods used and their perception of bushmeat hunting. The questionnaire contained five broad topics, (i) bushmeat hunting, (ii) cultural beliefs, (iii) bushmeat market and trade, (iv) last hunting trip, and (v) hunter profile. To explore emerging avenues of the discussion follow-up questions were asked during interviews.

Data collected occurred in September –November 2020 when restrictions were eased during Covid. Most of the hunters and people with insights about hunting in the respective villages were home and available for interviews. This allowed for comprehensive insights into hunting practices, including historical trends, motivations, and practices. The findings, therefore, provide a well-rounded perspective on bushmeat hunting, capturing both long-term patterns and potential short-term shifts influenced by the socio-economic conditions of the pandemic. Initial respondents were identified by the headmen, thereafter a snowball sampling approach was used until no new hunters were identified. A total of 147 semi-structured interviews were conducted with hunters in the 12 villages. An informed consent letter was read, explained, and signed by each respondent prior to each interview; and respondents were informed that they could stop the interview at any point. Each interview took approximately an hour to complete.

The interview protocol was reviewed and approved by the human ethics committee of Rhodes University (Ethics no. 2019-1065-3178). All the interviews were conducted in isiXhosa and were later translated into English. Extreme care was practiced avoiding leading questions.

3.2.4 Data analysis

Data were entered into Microsoft Excel for descriptive analysis. The responses from the questionnaire survey were systematically coded into thematic categories to identify recurring patterns and key insights. All statistical analyses were performed in the R Environment version 4.1.3. I assessed whether normality (Shapiro-Wilk test) and homoscedasticity (Levene's median test) assumptions for inferential testing were met, but found non-conformance of at least one of these conditions, even after transformation (Zar, 1999). The data were therefore treated as being non-parametric with appropriate univariate protocols being applied to address hypotheses pertaining to age and frequency of hunting. Inferential tests assumed significance at the 95% confidence level. T-tests were used to compare the means of different hunter attributes from close and far villages. Chi-square tests were used to compare different hunter attributes between hunters from close and far villages. Assuming normality of residuals and homoscedasticity of errors, I employed a Multiple Linear Regression Model (MLRM) to determine correlations between frequency of hunting and different hunter socio-demographic variables. These assumptions allowed for the application of MLRM, ensuring that the model's estimations are valid and unbiased.

3.3 Results

3.3.1 Hunter socio-demographic information

All the interviewees were male and with a mean age of 32± 9 years, ranging from 18 to 64. Nearly all the hunters (95%) reported that they were born and had lived in their respective village all of their lives. Approximately half (49%) had no formal or only primary school education, 32% had some high school education, 17% had completed matric, and 2% had a higher education qualification. The average household size and number of children under the age of 16 years were 8.9 ± 3.9 and 4.7 ± 3.0, respectively. Twenty-seven percent of the hunters reported to have some sort of employment; with the remaining 73% stating that they were unemployed. Only 7% of the hunters mentioned that they owned livestock. All of the unemployed hunters mentioned that they would still hunt even if they were employed. The

majority of hunters (93%) stated that they were taught how to hunt by a male family member, whilst others had learnt from males around their village.

Hala and Guquka villages in Hogsback had the most hunters (Table 3.1), followed by Xutidwele near the Hluleka forest. Villages closer to forests had more hunters (14.3 ± 4.3) than villages further away (10.2 ± 5.2), (t= 3.5, df= 145, p= 0.03), other than the villages in Hogsback which had the same number of hunters in both villages (Table 1).

Table 3.1: Number of hunters and household demographics in each of the surveyed villages in the Eastern Cape (villages closer to forests marked with *).

Forest	Village	No. hunters	Average age (years)	Average household size (people)	Average no. of social grants per HH
Hogsback	Hala*	20	33.0 ±7.0	9.2 ±3.2	4.6 ±1.5
	Guquka	20	30.4 ±9.7	8.7 ±4.0	5.3 ±2.7
Langeni	Mpafane*	12	32.3 ±5.1	8.3 ±3.0	4.2 ±2.6
	Lower gqobonco	6	33.2 ±7.0	11.0 ±3.4	7.0 ±3.0
East London	Boxwood*	8	42.6 ±5.1	7.8 ±2.8	4.4 ±2.5
	Needs camp	6	32.0 ±7.4	7.8 ±1.2	3.8 ±1.2
Hluleka	Xuthidwele*	18	27.6 ±8.0	9.8 ±4.2	6.1 ±3.5
	Ntengu	10	24.5 ±4.2	10.0 ±4.5	5.6 ±3.4
Silaka nature	Sicambeni*	14	31.0 ±6.6	9.0 ±4.6	5.0 ±3.5
	Ndikana	9	37.2±11.4	6.3 ±2.0	2.6 ±1.7
Mkambathi	Tanga*	14	31.1 ±8.2	9.5 ±4.0	4.0 ±3.0
	Ngubencuka	10	39.0±11.6	8. 0 ±5.0	3.0 ±2.0
Total/Mean		**147**	**32.1 ±9.0**	**8.9 ± 3.9**	**4.7± 3.0**

3.3.2 Motivation for bushmeat hunting

The primary motivations behind bushmeat hunting were culture (40%) and sport/competition (33%) (Figure 3.1). A further 20% hunted for recreational purposes, whilst only 4% mentioned that they hunt for income. The remaining 3% reported that they hunted as a recreational activity but would sometimes sell parts of the animals they caught. Seventy-one percent of the sport/competition hunters were from villages close to forests and 29% were from villages more distant from the forest patch. Both groups mentioned that they competed with other hunters from the same village and the best dogs and hunters would sometimes travel in minibus taxis to compete with dogs and hunters from other villages. No significant difference (χ^2=5.1; df= 4; p= 0.27) was observed in the hunting motivations between close and distant villages. All the hunters revealed that they enjoyed hunting and preferred bushmeat to any other animal-based protein. One of the hunters stated that *"We hunt because our forefathers hunted, it is in our blood, we enjoy it and no one can stop us."*

Only 7% of hunters sold some or all of their catch. The meat was mostly sold to elderly men who used to hunt but could no longer hunt due to old age or infirmity. Some hunters sold certain parts of their catch (e.g., skins, skulls, fat and body parts) to traditional healers, who used the parts for traditional medicine or for decorative purposes.

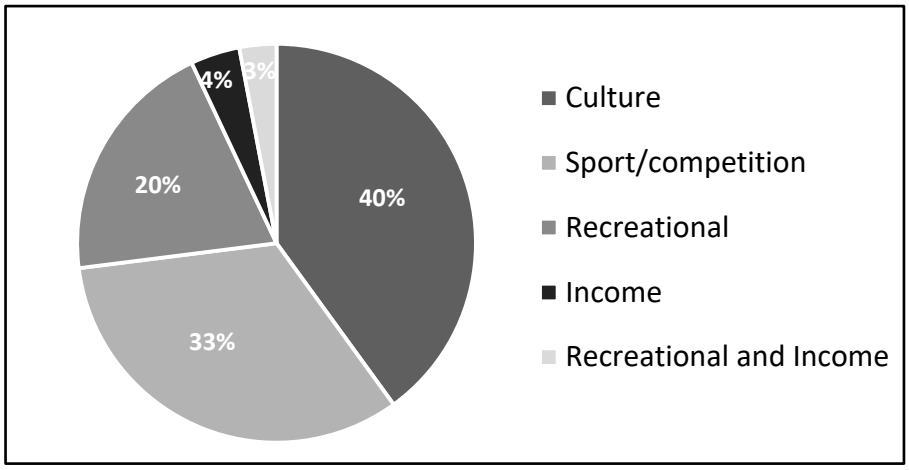

Figure 3.1: Motivations for bushmeat hunting in 12 Eastern Cape villages

Close to half (46%) of the commercial hunters were from the villages closest to the forest patches whilst the 54% came from villages further away (t=0.9; df= 9; p= 0.38). They all mentioned that they were unemployed and used the money they earned from selling their catch to assist the household. Hunters sold their catch privately at social grant pay points and to village residents who pre-ordered.

Most hunters consumed the catch amongst themselves or shared it with non-hunting males and their households. Twleve percent of the hunters mentioned that they brought their catch home to be consumed by all members of the household and stated that bushmeat was a dietary supplement and was mostly enjoyed by the males in the household. None of the hunters described bushmeat as a critical part of their livelihoods or food security.

3.3.3 Hunting methods and practices

All the hunters had harvested some mammal species during the 12 months preceding the survey. Forty-four percent said that they used a mix of hunting methods (Figure 3.3). This involved setting up or checking snares whilst hunting with dogs and sticks. A further 27%

attested to only using dogs and sticks as their preferred hunting method, whilst 17% only used snares.

Of the 17% that only used snares, only 2% were from villages further away from forest patches as they could not check snares frequently. Hunting with dogs and guns was reported by 12% of the hunters. More hunters from closer villages used snares compares to those from furthers villages. There was a statistically significant difference (χ^2=6.2; *df*= 3; *p*= 0.03) in the hunting methods employed by the hunters from villages at proximity to forests and hunters from villages further away with hunters from closer villages using more snares. Close to 80% of the hunters bred different types of hunting dogs and stated that dogs were important to hunters. One of the hunters said: *"My dogs are my pride and joy; I would kill anyone who would harm dogs."*

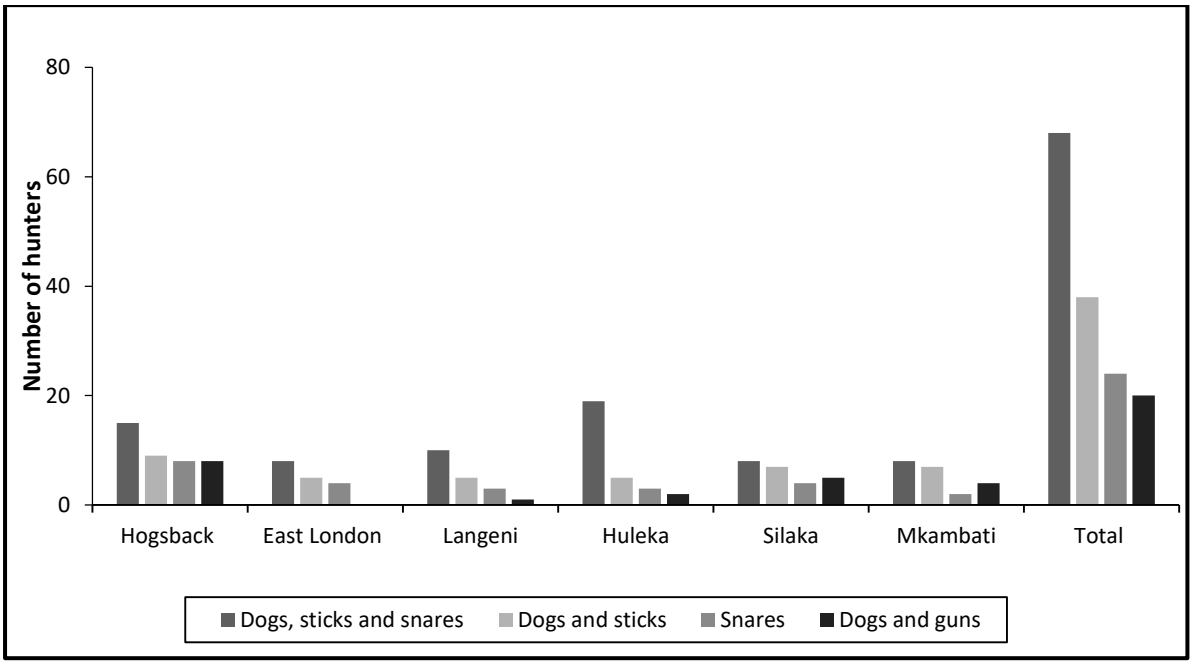

Figure 3.2: Number of hunters who employed different hunting methods in the forests

Most (71%) of the hunters reported that they hunt with other hunters because hunting was mostly a cultural activity or for sport/competition. However, 24% mentioned that they hunt both with other hunters and sometimes alone. Only 4% said they hunted alone; these were the hunters who hunted for income. Two-thirds (66%) of the hunters from the villages ≥10 km away from the forest patches mentioned that they hunted in groups of 5-10 hunters. Whilst 21% of the hunters from villages close to forests mentioned that they hunted in groups of 10 or more, there was no statistically significant difference when these were compared (χ^2=1.34; *df*=2; *p*= 0.51).

Hunters reported ten mammal species caught in forests of the Eastern Cape in the last 12 months (Figure 3.3). Bushbuck (*Tragelaphus scriptus*), common duiker (*Sylvicapra grimmia*) and cape porcupine (*Hystrix africaeaustralis*) were the most hunted species. Most of the species were not forest dependent but used forests at certain points in their life cycles. The samango monkey (*Cercopithecus albogularis labiatus*) and water mongoose (*Atilax paludinosus*) were the least caught species. In the 12 surveyed villages hunters attested to hunting 560 animals in the six forests between September 2019 and September 2020.

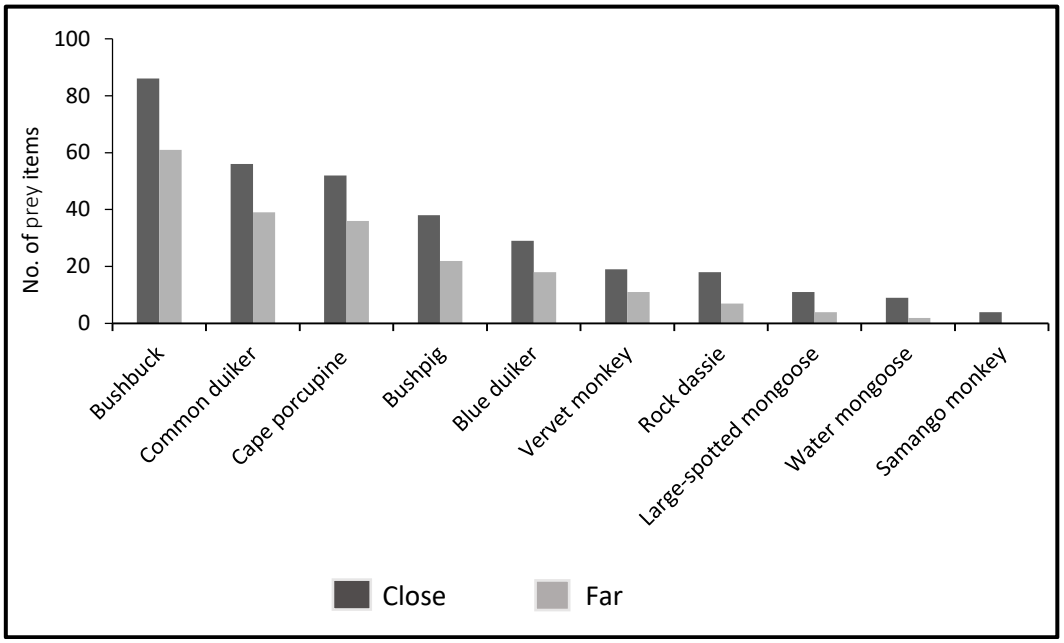

Figure 3.3: Species caught in the last 12 months by hunters from villages close to and further away from forests.

All the hunters mentioned that they had caught bushbuck in the year prior to the study. None of the hunters from the far villages had caught samango monkeys. The hunters from the villages close to forests caught significantly more animals per year (61.1 ± 67.0) than the hunters from villages further away (33.2± 4.0) (t= 8.8; df= 8; p= 0.0005). The most harvested species were bushbuck, common duiker, cape porcupine, and bushpig.

When hunters were asked about the frequency of hunting, 36% said rarely, 32% said irregularly, whilst 23% hunted monthly. Only 9% of the hunters mentioned that they hunted on a weekly basis. Hunters living close to the forests hunted more frequently than those living further away (χ^2= 8.3; df= 3; p= 0.03). All of the hunters that attested to hunting weekly were from close villages. Whilst most of the hunters from the villages at 10 km or more from the forest patches attested to hunting irregularly (30%) or rarely (45%).

The multiple linear regression models fitted on hunting frequency against different hunter socio-demographic variables (Table 3.2) showed an overall significant relationship (r^2= 0.181; *df* = 146; *F* = 3.822; *p* = 0.0004). There was a significant negative association between hunting frequency and age (*p*= 0.0004), suggesting that older hunters (> 35 years) hunted less frequently than younger hunters (< 35 years) (Figure 3.4) There was no other statistically significant relationship with any other socio-demographic variable (*p*>0.05).

Table 3.2: Results of multiple linear regression model fitted on if hunting frequency against different hunter socio-demographic variables.

Attributes	Estimate	std, error	r^2 value	p value
Age	**0.034**	**0.009**	**3.579**	**0.0004**
Education	-0.148	0.104	1.427	0.156
Household size	0.063	0.044	1.432	0.154
No. of children	-0.055	0.125	0.437	0.662
Employed	0.066	0.177	0.373	0.709
Owns livestock	0.186	0.329	0.566	0.572
Other sources of income	0.239	0.253	0.947	0.345
No. of social grants in HH	0.083	0.118	0.486	0.486

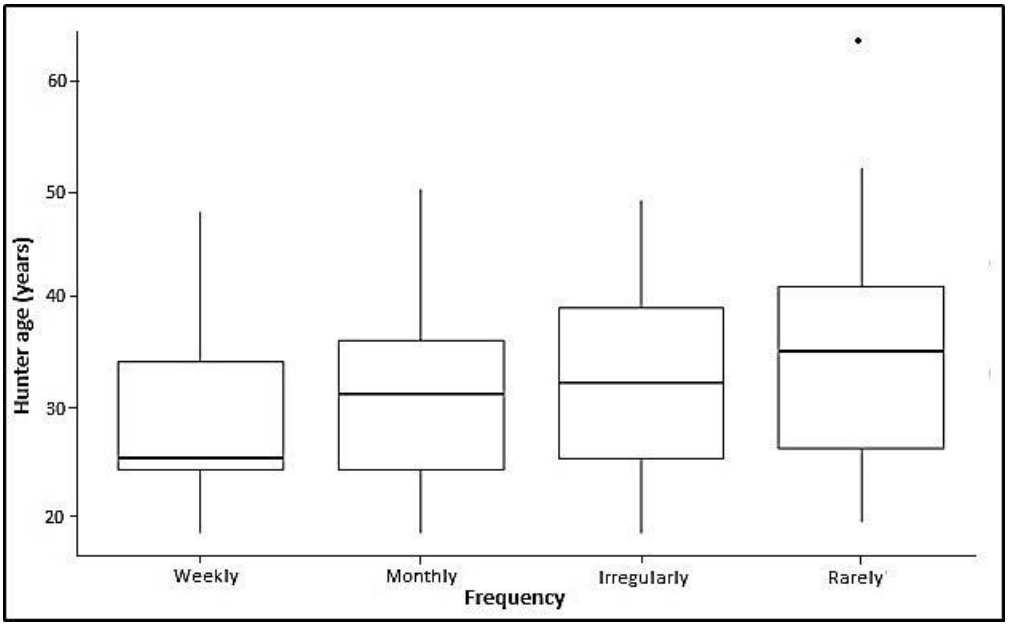

Figure 3.4: Relationship between age and hunting frequency. Boxplots represent the median (bold line), first and third quartiles (lower and upper box limits respectively), and 95% confidence intervals (whiskers). Black dots indicate outliers.

3.3.4 Hunter perceptions

All the hunters acknowledged that hunting was an illegal activity and if caught they could be arrested. Two of the 147 (1.4%) hunters reported that they had been arrested for wildlife crimes in the two years preceding the study. When asked if they would want their children to hunt, 84% of the respondents said no, whilst 16% said yes because it is part of their culture. Most of the hunters (76%) have hunted in the forests closest to their village for more than 10 years and these hunters state that they will continue hunting as they believe the forest belongs to the community and they have the right to access the forest as they please. Sixty-four percent of the hunters mentioned that in the last 10 years the number of hunters in their respective villages had increased due to unemployment and lack of opportunities. They stated that good hunters and their dogs were well respected amongst their respective communities and hunting peers. When asked if hunters from other or urban places came to hunt in the communal forests near their village; 86% of the hunters from near villages confirmed that other hunters from other villages hunted in the forest. An elderly hunter from Xuthidwele village near Hluleka nature reserve said: *"Long ago white men used to come hunt wildlife in this forest, they would pay the chief and ask us to track the animals for them."* When asked if the people still came to hunt in the forest, he said: *"They finished all the animals in the forest, now they don't come here anymore."*

Over half (55%) stated that they hunted in both communal and protected forests. A further 29% mentioned that they only hunted in communal forests as they feared law enforcement officers in protected forests. Sixteen percent of the hunters said that they hunted in protected forests as there was a higher likelihood that they would catch something there. All the hunters felt that the law was unfair towards rural hunters as they are never consulted when decisions are made about the wildlife on their land. Most hunters believed that the community would be able to manage its own resources as was the case in the past.

When asked what the forest meant for them, all the hunters observed the forest as a place where they can get free resources and enjoy themselves. Furthermore, 60% of the hunters mentioned that forests were part of their culture and heritage. Thirty-two percent stated that the forest had a spiritual value to them, as they felt at peace when they were in the forest and believe their ancestors were in the forest. Only 8% of the hunters mentioned that the forest had ecological value for them, through providing oxygen and fresh air.

3.4 Discussion

The aim of the current study was to assess bushmeat hunting practices by rural hunters living adjacent the indigenous forests of the Eastern Cape. Bushmeat hunting for consumption and trade represents a significant extinction threat to many wild terrestrial mammal species globally (Ripple et al., 2016; Evans et al., 2020). In Africa, research on bushmeat consumption is largely associated with people living in the tropical forests of western and central Africa, where bushmeat is the mainstay of local diets. In South Africa, research on bushmeat hunting in communal lands is very limited due to the secretive and illicit nature of the practice (Martins and Shackleton, 2019). The interviews revealed that bushmeat was mainly consumed by hunters and other, non-hunting males, rather than brought home for the family. Only 12% of the hunters attested to consuming the meat they caught with their families. Hunting was practiced mainly by young (mean= 32 years), unemployed men as a cultural activity and for sport. The Bushmeat trade was limited to a few hunters who sold to local elderly men. These results shed important light on bushmeat use patterns in South Africa, a region where such patterns have thus far been under-reported.

3.4.1 Motivation for bushmeat hunting

Social and economic drivers play an important role in the decision-making of bushmeat hunters (Marrocoli et al., 2018), with numerous socioeconomic triggers having been mentioned in studies in the tropics (Friant et al., 2015; Ripple et al., 2016; Luiselli et al., 2020; Thornley et al., 2022; Koné et al., 2023). All of these studies list bushmeat as the sole supply of protein and the primary source of income for many rural communities residing in and around tropical forests. Yet, in South Africa there still conflicting perspectives on the primary reasons behind bushmeat hunting (White, 2004; Hayward, 2009; Manqele et al., 2018; Nieman et al., 2019; Young et al., 2018; Sosibo et al., 2022). The handful of studies to date report poverty, culture, recreation, and financial gain as motivations (e.g., Hayward, 2009; Kashula and Shackleton, 2012; Young et al., 2018; Martins and Shackleton, 2019; Nieman et al., 2019; Sosibo et al., 2022).

Bushmeat hunting motivated by different socioeconomic issues is common throughout southern Africa (Martins and Shackleton, 2019). However, due to the illegal and discrete nature of the activity it is difficult to quantify, and many hunters are unwilling to disclose information about the practice. Such difficulties were limited in my study as the lead researcher is a Xhosa-

speaking male and most of the hunters were willing to share details on bushmeat hunting. In the rural villages of the Eastern Cape, bushmeat hunting was primarily a male activity done by young and middle-aged men, who were mostly unemployed and did not own livestock. This mirrors the findings of Rogan et al. (2018) who reported that in the Okavango Delta (Botswana), bushmeat hunting was predominantly a male activity (with only one female attesting to hunting), all the hunters were unemployed and only one-third owned livestock. In contrast, in the Amazon forests Torres et al. (2021) found that hunters were elderly men with families, who owned livestock.

In the study region most hunters consumed their catch with other hunters and shared with non-hunting males and young boys. Bushmeat hunting was not important to the subsistence and livelihoods of most of the hunters and their households, as only one-third mentioned that they brought their catch home and consumed it with the whole household. Even though the study was conducted during the COVID-19 pandemic, when economic hardships might have increased reliance on natural resources, bushmeat still did not play a significant role in household livelihoods in the region. This could be attributed, in part, to the South African government's COVID-19 relief grants, which provided financial support to unemployed individuals and may have reduced dependence on bushmeat as a subsistence resource. These findings support Manqele et al. (2017), who concluded that the motivation behind bushmeat hunting in KwaZulu-Natal, South Africa, was not a result of limited access to alternative sources of protein but was mostly a recreational activity. Such results contradict the findings of multiple studies in tropical forest regions where bushmeat hunting is the mainstay of household diets and is traded for income to meet livelihood needs (Ripple et al., 2016; Souto et al., 2019; Van Velden et al., 2020). In an assessment of bushmeat hunting in the Democratic Republic of Congo, Batumike et al. (2021) reported that more than 80% of rural households had an active hunter; hunters brought home small mammal species (e.g., rodents and small ungulates) for household consumption and larger ungulates were traded in urban markets where consumers preferred meat from large species.

Globally, a significant proportion of bushmeat studies suggest that the primary motivations for rural hunting is subsistence and trade (e.g., Lindsey et al., 2013; Rogan et al., 2018; Souto et al., 2019; Jones et al., 2019; Evans et al., 2020; Katuwal et al., 2023). Yet, in our study none of the hunters attested to hunting due to a lack of alternative protein sources or food insecurity. Hunters mentioned four primary motivations for hunting; culture, sport/competition, recreation

and income. Some hunters mentioned that they hunt both as a recreational activity and for income. A minority traded bushmeat locally, these hunters used bushmeat as a safety net to provide for their household due to unemployment. These hunters mentioned that they traded their catch for cash and used the money to purchase essential food supplies for their households.

The use of bushmeat as a safety net is well documented. In Ghana, West Africa, Schulte-Herbrüggen et al. (2013) noted bushmeat as an important resource in the livelihoods of rural communities in the area, especially in times of financial adversity. They further mention that during the agricultural lean season, cocoa farmers harvested and traded double the amount of bushmeat that was harvested during the cocoa season to accommodate their livelihood needs. Enuoh et al. (2014) reported higher rates of poaching in a protected area in Nigeria in times of vulnerability, which included war, environmental shocks, and seasonality. In a case study of the use of wild food in South Africa, Paumgarten et al. (2018) also echoed the same sentiments, reporting an increase in the frequency of consumption of wild food, including bushmeat, in times of food shortage. The safety net function of bushmeat hunting is evident as the harvesting of wild animals increases during times of adversity and hardship. In Limpopo Province (South Africa), Hunter et al. (2007) confirmed an increased dependency on natural resources following the death an adult in the household. In their study the consumption of insects increased immediately after the death of the head of the household.

Understanding the motivation of bushmeat hunting at a local level is key for conservation as this knowledge can guide decision-makers in species management and rehabilitation efforts (Manqele et al., 2018). As hypothesised, the motivations behind bushmeat hunting varied in the study region with culture reported as being the key motivation by hunters across all villages. Culture plays an important role in the decision-making of resource users in complex, adaptive social-ecological systems (Torres et al., 2021). The inadequate knowledge of the cultural drivers behind bushmeat hunting presents conservation professionals with a challenge in including cultural factors into management programs (Poe et al., 2013).

3.4.2 Hunting methods and practices

Most of hunters employed a combination of hunting methods. Hunters set up wire snares on animal trails in and around the forests, then deploy dogs to search and chase wild animals within the forest. When the dogs cornered an animal, sticks with a knob at the top (knobkerrie) are used to beat the animal to death or the animal is shot. Some hunters attested to only using

dogs and sticks/guns, whilst some only used snares. The use of a combination of hunting methods is well documented elsewhere too (Carpaneto and Fusari, 2000; Holmern et al., 2006; Fuashi et al., 2019; Erena et al., 2020). In a survey of hunting practices in a farming village in Ethiopia, Erena et al. (2020) reported that most of the respondents claimed to use a combination of gin traps, spears and dogs to hunt. The use of combined hunting methods was also reported by Pattiselanno and Nasi (2015) in Indonesia where hunters used a combination of passive and active hunting techniques to obtain different species and higher quantities. The hunters mentioned that using a combination of hunting methods concurrently increases their chances of capturing prey and increased their catch per unit effort.

Snares were not favoured by hunters residing in villages further away from the forest patches as they could not be checked frequently because of the distance they had to travel. The use of snares was common amongst hunters from villages closer to the forests as they could be frequently checked. The use of snares is a widespread amongst bushmeat hunters globally (Lindsey et al., 2011; Watson et al., 2013; Lindsey et al., 2013; Loveridge et al., 2020). In the Serengeti, Hariohay et al. (2022) mention that snares are the primary hunting method as they are easy to make and very effective. However, snares are widely criticized for their unselective nature and cruelty (Holmern et al., 2007; Harmsen et al., 2021; Mwampeta et al., 2021). Loveridge et al. (2020) reported that 80% of large carnivores in 16 protected areas in Zimbabwe showed signs of having been trapped in snares. They further mentioned that large carnivores appear to be highly vulnerable to being snared as accidental bycatch due to being of a similar size to the target species. From a conservation perspective, snares are regarded as ‘nightmares’ as they pose a threat to all wildlife species which may lead to local extinction (Kendon et al., 2022).

The majority of the hunters used dogs as a means of hunting. All the hunters who hunted for sport or competition bred dogs which were used in the competitions with other hunters from the same village or different villages. Hunters bred different breeds of dogs which were used at different stages during a hunt. For example, sniffer dogs were released first during a hunt to smell where the prey were and chase them out of the dense bush. Most of the hunters also bred greyhounds, used to chase down the prey. Chambers (2020) mentions that hunting with dogs has a long history in South Africa. Taxi hunters are said to cause the most destruction, because they transport large numbers of hunting dogs in minibus taxis, release them in the forests and place bets on the outcome (Chambers, 2020). Dogs are important for bushmeat hunters

worldwide (Mbotiji, 2002; Wright and Priston, 2010; Rogan et al., 2017; Evans et al., 2020; Chambers, 2020). Hunters use dogs to locate prey and to chase animals into positions which makes them easier to shoot or kill and fetch animals once shot (Wright and Priston, 2010). Manqele et al. (2017) confirmed the importance of dogs for bushmeat hunting, stating that more that 90% of hunters in KwaZulu-Natal, South Africa, used them. They further mention that spears and sticks were used to back up the dogs. Dogs were very important to the hunters in the Eastern Cape. One of the hunters in the region who owned four greyhounds mentioned that he would kill for his dogs.

As hunting is primarily motivated by culture and sport, most of the hunters in the study area stated that hunting was a social occasion. Most hunted in groups of 5-10 hunters armed with dogs, sticks and sometimes guns. Competition was based on which dog was fastest and caught the most prey. Hunters also reported that they compete with dogs and hunters from other villages. These competitions typically have between 10-20 hunters (sometimes more) and more than 30 dogs. Sport hunting is usually associated with formal hunting reserves, where urban elites apply for permits to hunt certain species and go on weekend or holiday hunting trips (Mangan and McKenzie, 2013). In these hunting reserves rules and regulations are in place to guide the hunters on hunting procedures, species, and number of animals to be hunted (Bollig and Olwage, 2016), unlike the dynamics in the rural villages.

In rural settings the impact of unregulated sport hunting can have severe effects on prey populations (El Bizri et al., 2015). In the Amazon forests of Brazil, sport hunters extend large sums of money to undertake their hunts (Bizri et al., 2015). This suggests that in the region sport hunting is conducted by wealthy urban residents who travel to rural areas to hunt. White (2004) echoed the same sentiments in the subtropical forests of the Eastern Cape as urban inhabitants were reported to hunt in the forests near the surveyed rural villages. My respondents also mentioned that hunters travel to different locations to take part in hunting competitions. Also, a hunter reported that the reason they had few animals in the communal forest was because of urban hunters who hunted all the animals in their forest. Most of the hunters attested to hunting in protected areas due to the limited abundance of prey species in communal forests. They stated that most of the wildlife has been fenced within the protected areas and they were only left with ‘empty forests’ as animals run into the nature reserves. This was also reported by Hayward (2009), who mentioned that bushmeat hunting in Dwesa and Cwebe protected areas was a result of the over-exploitation of the neighbouring communal forests.

The hunters mentioned that they targeted mostly ungulate species because of their larger size and hence were a greater prize in the competition. Opportunistic hunting was prevalent throughout the study area as hunters caught and consumed whatever was available. Bushbuck (*Tragelaphus scriptus*), common duiker (*Sylvicapra grimmia*), cape porcupine (*Hystrix africaeaustralis*) and bushpig (*Potamochoerus larvatus*) was the most commonly captured prey. These results correspond with numerous mammal assessments conducted in the forests of South Africa which indicate high occupancy rates for these particular species (Hayward et al., 2005; Lawes et al., 2007; Ehlers-Smith et al., 2018; Sosibo et al., 2022). Hunters mentioned that bushpigs are difficult to catch as they are nocturnal species and sometimes injured or killed dogs with their tusks. Generally, hunters from the villages close to the forest patches hunted more frequently than hunters from villages further away. Also, younger hunters hunted more regularly than older hunters. This was also the case in the hunting communities in Nigeria, where Fraint et al. (2015) found that most of the hunters were young as they were more energetic and could move through the forest faster. However, in the Congo Basin most of the hunting was done by elderly hunters (Tieguhong and Zwolinski, 2009). They also reported a greater catch per unit effort as they were more experienced than younger ones.

3.4.3 Hunter perceptions

All the hunters had a sense of ownership over the wildlife in both the communal and protected forests. Throughout the study area the hunters did not appreciate the fenced protected areas, as they believed that they were able to manage their own natural resources. Hunters in both close and far villages in the Coastal region believed that communal forests were empty because all the game had escaped into the protected areas. Hayward (2009) also noted a depletion of mammal species in the communal forests adjacent Dwesa and Cwebe nature reserves. However, Hayward (2009) concluded that this was due to the overexploitation of wildlife by hunters and did not consider that the mammal species may move into the adjacent protected areas. Though all the hunters knew that hunting was illegal they still mentioned that they will not stop hunting as it was part of their culture, and they enjoyed the thrill of hunting. In the Serengeti, bushmeat hunters continued to hunt even though the benefits of hunting are far less than the cost of being injured or arrested (Knapp, 2012). Hunting remains an important activity for the many rural communities and most hunters will continue hunting even when landscapes are patrolled, or dangerous animals are present.

All the hunters mentioned that they enjoyed hunting as it was part of their cultural identity. Cultural perceptions have been acknowledged as strong predictors of bushmeat hunting, with hunters in many rural settings attesting to have learnt the art from other men in their family or village (Morsello et al., 2015; Van Vliet, 2018; Dell et al., 2020). In the study area, hunting was viewed as a sociocultural activity which was passed down from generation to generation. In all the villages the hunters mentioned that young boys are trained by men or older boys on where and how to hunt.

Forests are important to all the respondents in the study as it was a place where they could gather free resources (e.g., firewood, bushmeat, medicinal plants) important for their livelihoods and culture. To some, the forest was a place where they could connect with their ancestors and experience spiritual upliftment. The indigenous forests are important to the Xhosa people of the Eastern Cape as they provide medicinal plants, and many believe it is where their ancestors are (Cocks et al. 2012).

3.4.4 Influence of forest proximity on hunting practices

More than half of the hunters in the study came from the villages close to forests. Proximity to wildlife areas plays a significant role in bushmeat hunting patterns and practices (Foerster et al., 2011; Ceppi and Nielsen, 2014; Brodie and Fragoso, 2021). In Gabon, Foerster et al. (2011) reported that households in villages close to forests consumed more bushmeat than households from villages further away. This was also the case in a comparative study of bushmeat consumption between ten tribes in Tanzania, with the villages close to wildlife areas having more hunters and consuming more bushmeat (Ceppi and Nielsen, 2014) because of the effort hunters have to put in traveling is less than their counterparts from villages further away.

The frequency of hunting also differed by village proximity, with the hunters from the villages close to the forest hunting more often. Hence, these hunters caught more animals than the hunters from villages further away. Nuno et al. (2013) also reported that the distance to a national park had a negative effect on hunting prevalence and therefore the communities in distant villages consumed less bushmeat. This was the same in the Serengeti (Fischer et al., 2104). My results also show a difference in the hunting methods employed by the hunters from the villages at close proximity to forests compared to those from villages further away. Though most of the hunters used dogs and sticks, snares were not preferred by hunters from the villages further away to forests as these could not be checked frequently.

On the contrary, the hunting motivations were similar as both sets of hunters primarily hunted for culture and as a recreational activity. Equally, trade was not an important motivation for hunting irrespective of distance to the forest. These findings oppose numerous studies conducted in the global tropics that report trade as the primary motivation for bushmeat hunting (Souto et al., 2019; Ferreira da Silva et al., 2021; Randolph et al., 2022).

3.4.5 Conclusion

This study provides insights on the bushmeat hunting practices of rural communities residing in proximity to indigenous forests in the Eastern Cape. Highlighting that bushmeat hunting is a complex social-ecological system characterized with several feedbacks and uncertainties. I conclude that in the region bushmeat is not an important source of protein as reported for many rural communities in tropical forests. In the study area, bushmeat hunting was mostly a cultural and sporting activity typically done by young and middle-aged men. The villages close to the forests had significantly more hunters, hunted more often and caught more animals than hunters from the distant villages.

Hunting is an important cultural activity for the indigenous people of the region and will continue to so for the foreseeable future. I recommend that national and provincial government establish wildlife management strategies that are sensitive to the cultural values of the local people in the area. This will be achieved through adequate consultation of rural communities prior to establishment of laws that govern the use forest resources, including wildlife. I further recommend the amendment of the current hunting legislation to accommodate hunters from rural villages, as the current laws do not do so. Also, legislation should recognise and set frameworks to manage cultural resources such as bushmeat.

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CHAPTER 4

Mammal species diversity under hunting pressure in the forests of the Eastern Cape

Picture of hunters leaving a forest in the Eastern Cape with their catch (Picture shared by an interviewed hunter)

4.1 Introduction

Anthropogenic impacts to biodiversity have heralded the Anthropocene era, characterised by human activities threatening the functioning of natural systems (Roberts et al., 2021). Consequently, loss of biodiversity due to human actions is currently one of the greatest environmental issues facing humankind (Lindsey et al., 2022; Lunstrum and Bose, 2022). Yet, human well-being remains a concern especially for developing countries globally (Everard et al., 2020). Humanitarians and people concerned with social reform champion improving the livelihoods of humans, mostly focused on rural, impoverished communities (Turner et al., 2021). On the other hand, environmental practitioners and ecologists are invested in the conservation and sustainable use of species and natural landscapes (Edwards et al., 2021). Numerous studies examining how humans have contributed to the global decline of biodiversity, list bushmeat hunting as a key pathway with respect to mammal species loss (Abernethy et al., 2013; Ripple et al., 2016; Deith and Brodie 2020; Evans et al., 2020). Others have attempted to bring a human voice, highlighting the importance of bushmeat hunting to

rural livelihoods and culture (Ntoko and Schmidt, 2021; Djagoun et al., 2022). Several studies have shown how bushmeat is a vital and sometimes the only source of protein for many rural communities globally (e.g. Van Velden et al., 2020; Stone and Stone, 2022; Trefon, 2023).

In the different global assessments on wild species use conducted in the last decade sustainable use of natural resources had been one of the key agendas (Diaz et al., 2019; Fromentin et al., 2022). It has been recognised that the harvesting of wildlife, especially terrestrial vertebrates, has reached unsustainable levels in several regions of the world (Ripple et al., 2016; Diaz et al., 2019; Morton et al., 2021). Research has shown that the harvesting of terrestrial mammals takes place in a range of ecological, socio-cultural, governance and management contexts which affect the outcomes for sustainable use (Fromentin et al., 2022). It is well documented that the sustainability of bushmeat hunting is largely driven by socio-economic challenges, trade, recreation, and sport rather than solely by hunting for subsistence (Ripple et al., 2016; Fromentin et al., 2022; Stone and Stone, 2022). As such, for governance responses to be effective they need to address the various context specific drivers affecting bushmeat use accommodating differences among species, practices, sites and scales (Van Velden et al., 2020). The impacts of hunting on the diversity of mammal species differs depending on the biological and ecological characteristics of the species and the management systems they are under (Benitez-Lopez et al., 2017; Brodie et al., 2021). Commonly, the impact of hunting is lessened when species population growth rates are high and where hunting is well managed (Abernethy et al., 2013; Otto, 2018; Perez et al., 2022).

Bushmeat hunting is closely linked with the threat of defaunation for numerous mammal species globally (Ripple et al., 2016; Krause and Nielsen, 2019). The primary reasons for bushmeat hunting are said to be for human consumption (Wright and Priston, 2010; Van Vliet and Mbazza, 2011; Rogan et al., 2018; Van Velden et al., 2020), trade (Lindsey et al., 2011; Souto et sl., 2019; Randolph et al., 2022), traditional medicines (Lee et al., 2014, 2020; Friant et al., 2015), decorative purposes (Ripple et al., 2016; Chiatea et al., 2022), culture (Friant et al., 2015; Van Velden et al 2020) and recreation (Van Vliet and Mbazza, 2011; Rogan et al., 2018; Van Velden et al., 2020).

Understanding bushmeat hunting and how it can hinder or help efforts towards equitable conservation is a complex social-ecological problem (Lischka et al., 2018). The hunting of wildlife is a result of social and ecological dynamics, for instance factors such as poverty, food security, culture, development and infrastructure, land-use rights, governance and corruption,

and human population growth may all influence bushmeat hunting in some way (Van Velden et al., 2020). Previous research has revealed the intricacy of the social-ecological factors influencing bushmeat hunting and consumption (e.g., Lischka et al., 2018; Van Velden et al., 2020; Froese et al., 2022), highlighting that these kinds of complex social-ecological systems are defined by feedback dynamics characterized by uncertainty, hence it is difficult to predict the outcomes (Liu et al., 2023). Incorporating complexity in the assessment of bushmeat hunting is essential, as the practice is not deterministic, predictable nor is it mechanistic (Nuno et al., 2014; Van Vliet et al., 2015; Van Velden et al., 2020). The practice of bushmeat hunting is not just a matter of humans hunting animals but has social components that influence the system, which go beyond the hunter and the animal being hunted (Van Velden et al., 2020). Indeed, hunting intensity and patterns are extremely influenced by a variety of social drivers that influence hunter decision making (Torres et al., 2022). In turn, bushmeat hunting is mostly determined by cultural drivers, cash needs, and the combination with other economic activities (Van Vliet et al., 2015; Van Velden et al., 2020; Lemos et al., 2024).

Evaluating species diversity is one of the most commonly used indicators to assess wildlife populations (Ehlers-Smith, 2017). However, wildlife surveys remain challenging due to logistical and/or financial limitations, more so during long-term studies in inaccessible or dangerous areas (Satpathy, 2018). Furthermore, the behaviours of certain species might constrain detection through some methods (MacKenzie et al., 2006; Nichols and Williams, 2006). Whilst abundant species and those with small home ranges may be easily detected, cryptic, nocturnal, or infrequent species with larger home ranges may be difficult to detect (MacKenzie et al., 2006). Hence, the field detection method used can influence the results of species diversity surveys (Fragoso et al., 2016). The ideal method should facilitate high detection rates of the target species, accuracy, and cost-effectiveness (Raymond et al., 2020).

Species diversity has two primary components, species richness which is defined as the total number of species in a community (Storch et al., 2022) and relative abundance of each species (Wale et al., 2022). These can be determined using a range of approaches such as, citizen science, systematic field surveys and local ecological knowledge (LEK) (Fledman et al., 2021). The use of systematic field surveys such as line transects to record terrestrial mammal diversity are frequently used in wildlife studies as their regarded reliable and cost-effective methods (Fragoso et al., 2016; Moore et al., 2020; Stephenson, 2020). During line transect surveys both direct (e.g., animal sightings) and indirect (e.g., spoor, dung and digging) evidence can be observed as signs of species richness and can also be used to determine species abundance

(Fragoso et al., 2016). However, line transect surveys require intensive sampling effort (Braga-Pereira et al., 2022) and can be dangerous at times. Thus, the use of complementary sources such as local ecological knowledge (LEK) can also be useful.

LEK is the knowledge local people have about local ecological systems and species, which is gained through long-term personal observations and experience (Das et al., 2021). LEK has contributed to the scientific knowledge of species for millennia (Jessen et al., 2022), as scientists have recorded knowledge of different species from local inhabitants globally (Aswani et al., 2018). To date, LEK has been used to collate data on different habitats, human–wildlife conflicts, uses of biodiversity, the ecology and behaviour of various species (Joa et al., 2018; Braga-Pereira et al., 2022). LEK provides an economical and comprehensive understanding of ecological systems that at times equals or surpasses that of more scientific ecological methods (Krause et al., 2020; Zhang et al., 2020; Das et al., 2021). Hence, combining LEK and conventional methods used in wildlife research improves the detection of species and thus potentially contributes to improved conservation goals (Ens et al., 2021). Though the integration of ecological and social science methodologies in conservation studies has gained traction over the past few decades (Meine et al., 2006; Bennett et al., 2017; Chua et al., 2020), only a handful of studies have used mixed-methods to assess the impacts of bushmeat hunting on wildlife species diveristy (e.g., Blair-Brake et al., 2014; Peros et al., 2021; Saylors et al., 2021; Bragga-Pereira et al., 2022).

The few studies that have used mixed-methods to assess the effects of bushmeat hunting on mammal species diversity have shown that the integration of social and ecological methods yields more reliable results than using a single method (e.g., Parry and Peres, 2015; Brittain and Rowcliffe, 2019; Torrents-Tico et al. 2021). In Kenya, Torrents-Tico et al. (2021) used a combination of LEK and camera trap surveys to assess carnivore populations. They highlighted the importance of complementing scientific methods with other knowledge systems to enhance the understanding of species status. Brittain and Rowcliffe (2019) used a mixed-method approach to assess hunted wildlife populations in two villages adjacent the Dja Faunal Reserve in Cameroon through participatory hunter interviews. In the Amazon, Parry and Peres (2015) integrated community based LEK into monitoring wildlife species under hunting pressure. The study revealed that LEK-based approaches have significant potential for community-based wildlife monitoring as well as cost-effective monitoring of threatened forest species.

Bushmeat hunting, especially in the less biodiverse subtropical forests, poses a major threat to many wild mammal populations (Sosibo et al., 2022). In South Africa, forests are the smallest biome (Moir et al., 2021). Despite their small size, forests are of high conservation value, harbouring 14% of the country's mammal species (Ehler-Smith et al., 2023). Most of the forests in South Africa occur as small fragments in the Eastern Cape province (Ngcobo et al., 2022); a province characterised with high unemployment rates and poverty contributing to a reliance on forest resources (Ngumbela, 2021). Hence, bushmeat hunting has been reported throughout the indigenous forests (Martins and Shackleton, 2019), potentially threatening the indigenous fauna that form an integral component of the forest ecosystem.

In South Africa, research using mixed-methods to assess the impacts of bushmeat hunting on wildlife is limited. In the country the interweaving of traditional ecological methods like line transects with social methods like LEK in bushmeat studies is still an under-used multidisciplinary method (Peros et al., 2021). Burt et al. (2021) used mixed-methods to assess mammal diversity in different arid landscapes in South Africa. They concluded that integrating LEK into mammal species diversity surveys can be useful for long-term studies and it provides knowledge on species that are difficult to detect. In the region LEK has been used to mostly assess plant species diversity and use (e.g., Kota and Shackleton, 2015; Maroji, 2017; Shackleton and Shackleton 2018; Mdweshu and Maroji, 2020).

Within this context, the aim of the study was to assess mammal species diversity under hunting pressure in the indigenous forests of the Eastern Cape using a mixed-methods approach. As the evidence suggests that uncontrolled and excessive hunting occurs in communal land compared to protected or privately owned land (Ripple et al., 2016; Nasi et al., 2021), I compare mammal species diversity within fenced protected forests and neighbouring unfenced communal forests using line transects and LEK surveys. To also assess other human impacts that may affect species diversity, I also compare the level of anthropogenic disturbances between the forest types. Based on these objectives and on the prior research on bushmeat hunting in communal and protected lands, I make the following predictions, (i) bushmeat hunting will be more prevalent in the communal forests resulting in lower species diversity, (ii) communal forests will also exhibit more signs of human disturbances than protected forests which will also contribute to the reduced species diversity, (iii) increased hunting pressure will differ between the forest types, and (iv) hunting pressure will have a negative effect on mammal species diversity.

4.2 Methods

4.2.1 Study area

See Chapter 1

4.2.2 Site selection

See Chapter 1

4.2.3 Survey methods

Ecological data was collected in the form of line transect surveys in the 10 randomly selected forest patches. Social data was sourced through conducting LEK surveys with local inhabitants from the 12 selected villages. Interviews were also conducted with local experts from the four protected areas; these were either the reserve mangers or field rangers who had knowledge on forest mammal species. The survey included all the forest dwelling mammals and mammals which used forests at certain intervals. All introduced mammals and bats were excluded from the survey.

4.2.3.1 Line transects

The selected forests were surveyed during the summer of 2020 (September to November) when forest mammals are most active. Multiple, variable-width 3 km line transects were walked at an average speed of 1.5 km/hour in all the forest patches by four observers. A dawn (04:00 - 06:00) and a dusk (17:00-19:00) survey were conducted in each of the 10 forest patches (16 observational hours for each forest patch). Observers walked five meters apart on existing footpaths through each of the forest patches. The Afromontane communal forest patches were subjected to 16 transects and 32 observational hours. Whilst 32 transects (64 hours) were walked in both the Coastal communal and the protected forests, respectively. A total of 80 line transects were conducted to determine mammal species richness and abundance in the study forests. Observers recorded direct terrestrial forest mammal species sightings and indirect evidence of mammal presence, such as spoor, dung, calls and diggings following Hayward et al. (2005). For each sighting, the species and the number of individual animals was recorded. For indirect evidence, dung, spoor, diggings, and ring barking were identified on sight, and if observers were uncertain, photos were taken for later identification. Signs of human activity in the forests (woodcutting, snares, bark stripping, etc.) were also recorded. Species abundance was taken as the number of observations of forest mammal evidence on each transect. Relative

abundance was calculated by dividing the number of observations of forest mammal evidence by the number of observer hours on each transect.

Duning field surveys, detection conditions were relatively uniform, as all surveys were conducted during the summer season, when vegetation cover, light availability, and animal activity levels were consistent across surveyed forest patches. These conditions helped minimize variability in detection probabilities, reducing the need for additional corrective measures. The study did not use DISTANCE software to adjust for detectability bias.

Field assistants were either experienced field rangers from the respective Eastern Cape Parks and Tourism Agency managed nature reserves or postgraduate Zoology students who were trained to identify different mammal species and their signs. In most cases the field rangers were more efficient observers than the students as they had more field experience. To overcome any bias and incorrect observation all student observations were confirmed by the lead research or by one of the field rangers.

4.2.3.2 Local ecological knowledge

LEK surveys were conducted using semi-structured questionnaire comprising of both open- and closed-ended questions, administered via face-to-face interviews with regular forest users, hunters and local experts (≥ 18 years). I used Google Earth Pro (version 7.3) to count all the households in each village (assuming 1 building = 1 household), this was then followed by pilot surveys in each of the villages. To allow every household a chance to be selected, the simple random sampling method was used to randomly select households to interview in each of the 12 villages. Of the 486 household interviews conducted, 258 respondents mentioned that they were personally the regular forest user within the household. During the pilot surveys the headmen and chiefs identified known hunters in each of the villages, using the snowball sampling method these hunters identified other hunters to interview. This resulted in a total of 147 hunter interviews in the 12 villages. At each of the protected forests two local experts (reserve manager or field rangers) were also interviewed (n=10).

Amongst the 12 villages, a total of 415 questionnaires were conducted with regular forest users (258), hunters (147) and local experts (10). Most (64%) of the respondents were from the villages around the Coastal forests as eight villages were surveyed in the area and only four villages neighbouring the Afromontane forests were surveyed. All the respondents had knowledge on the mammal species in the forests around their respective villages, as they all

spent considerable periods in the forests, and all reported the forest mammals known to occur in the area. To avoid misidentification, colour pictures of the 14 small and medium-sized mammal species found in the Eastern Cape forests by Hayward et al. (2005) were shown to each respondent with the vernacular name (Annexure 3). The species richness of forest mammals was recorded as the total number of species each respondent had personally observed in the forest in the past 12 months. To assess mammal species abundance, I asked the interviewee to estimate the abundance for each species using a Likert scale: 0= absent; 1= low; 2= medium; 3= high abundance following Braga-Pereira et al. (2021).

An informed consent letter was read, explained, and signed by each respondent prior to each interview; and respondents were informed that they could stop the interview at any point. Each interview took approximately one hour to complete. The interview protocol was reviewed and approved by the ethics committee of Rhodes University (Ethics no. 2019-1065-3178). All the interviews were conducted in isiXhosa and were later translated to English. Extreme care was practiced ensuring leading questions were avoided. To explore emerging avenues of the discussion follow-up questions were asked during interviews. The questionnaires (Appendix 5) solicited data on extraction and use of NTFPs, food security, knowledge of mammal species present in forest, community-based natural resource management (CBNRM), bushmeat hunting and the general demographics of each household/hunter/local expert.

The number of species each respondent mentioned was used to compare the differences in knowledge of species richness and abundance between different respondents. Hunting pressure was taken as a function of bushmeat offtake and hunting frequency, where hunting frequency is how often a hunter attested to hunting in the 12 months prior to the research.

4.2.4 Data analysis

The data was entered into Microsoft Excel to allow for descriptive analysis. Relative species abundance of each forest was calculated by dividing the number of observations of evidence by the number of observer hours on each transect. Species richness was taken to be the number of mammalian species or signs noted per transect and per forest. The Shannon-Weiner species diversity index was calculated to take account of the relative abundance of each species. Initial assessment of whether normality (Shapiro-Wilk test) and homoscedasticity (Levene's median test) assumptions for inferential testing were met, indicated non-conformance of at least one of these conditions, even after transformation (Zar, 1999). The dataset was therefore considered

as being non-parametric with appropriate univariate protocols being applied to address hypotheses. Inferential tests assumed significance at the 95% confidence level. All statistical analyses were performed in the R Environment version 4.1.3. For the LEK data, the t-test was used to compare the means of different respondent variables between the Afromontane and Coastal villages. As data was normally distributed, simple regression and Multiple Linear Regression Models (MLRMs) were used to determine correlations between independent variables and different response variables.

4.3 Results

4.3.1 Forest mammal diversity assessed using line transects

The line transects revealed 12 different mammal species (mean species richness: 7.6 ±1.3 per forest) in the protected forests, eight (mean species richness: 5.3 ±1.4 per forest) in the Afromontane communal forests and seven (mean species richness: 3.3 ±1.6 per forest) in the Coastal communal forests (Table 4.1). Both the Afromontane and Coastal communal forests exhibited similarities in species richness and diversity (Figure 4.1). Blue duiker (*Philantomba monticola*), bushbuck (*Tragelaphus scriptus*), cape porcupine (*Hystrix africaeaustralis*) and common duiker (*Sylvicapra grimmia*) were the most common species detected in all the three forest types.

Table 4.1: Mammal species detected in the three forest types and their mean relative abundance (evidence per observer hour). Species not detected on the line transects listed as undetected

Common name	**Scientific name**	**Coastal Protected (n= 4)**	**Afromontane communal (n= 2)**	**Coastal communal (n= 4)**
Blue duiker	*Philantomba monticola*	0.4±0.1	0.3±02	0.1±0.1
Bushbuck	*Tragelaphus scriptus*	0.5±0.2	0.3±0.1	0.2±0.1
Bushpig	*Potamochoerus porcus*	0.3±0.1	0.2±0.1	0.1±0.1
Cape porcupine	*Hystrix africaeaustralis*	0.5±0.3	0.2±0.1	0.2±0.1
Common duiker	*Sylvicapra grimmia*	0.6±0.3	0.3±0.1	0.2±0.1
Large-spotted genet	*Genetta tigrine*	0.1±0.1	Undetected	Undetected
Mole/mole rat*	-	0.2±0.1	0.1±0.1	Undetected
Samango monkey	*Cercopithecus labiatus*	0.2±0.1	0.4±0.2	Undetected
Tree hyrax	*Dendrohyrax arboreus*	0.1±0.1	0.1±0.1	Undetected
Rock hyrax	*Procavia capensis*	0.1±0.1	Undetected	0.1±0.1
Vervet monkey	*Cercopithecus aethiops*	0.2±0.1	Undetected	0.2±0.1
Water mongoose	*Atilax paludinosus*	0.1±0.1	Undetected	Undetected
Species richness		**12**	**8**	**7**

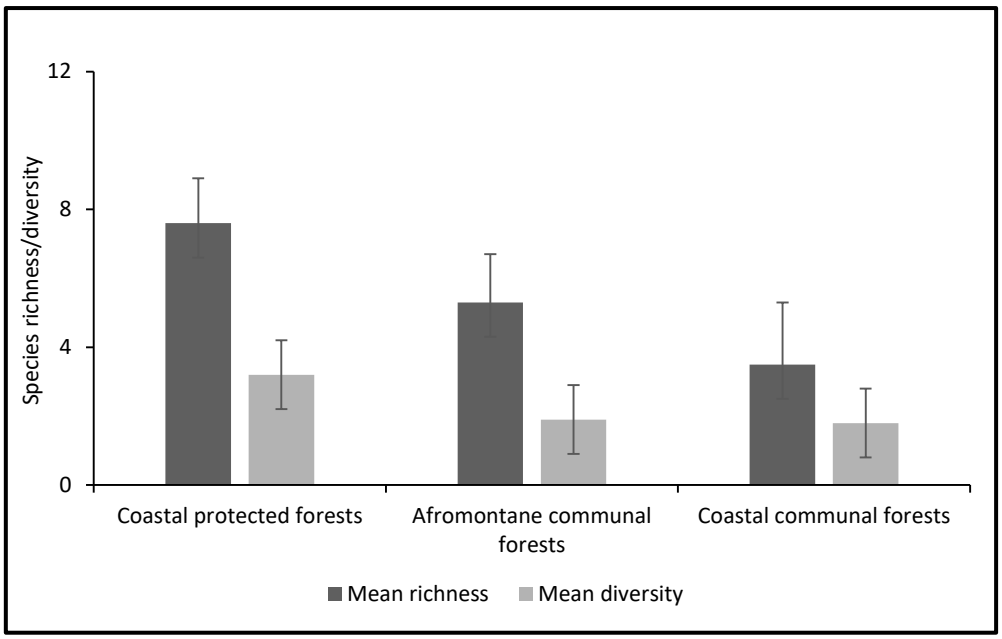


Figure 4.1: The mean (±SD) relative species richness and diversity (Shannon-Weiner index) of forest mammal species in three forest types.

There was a highly statistically significant difference in the mean species richness between the three forest types (ANOVA: F= 61.1; df= 2; p= 0.000003); the Coastal protected forests had a higher species richness than both the Afromontane and Coastal communal forests. Contrary, there was no significant difference in the species diversity amongst the three forest types (F=1.6, df= 2, p= 0.21). The large-spotted genet (*Genetta tigrine*) and water mongoose (*Atilax paludinosus*) were not detected in either of the communal forests. In the Afromontane communal forests samango monkeys (*Cercopithecus labiatus*) were the most abundant species, mostly detected in Hogsback forest (86%), whilst in the Coastal communal forests and the protected forests the common duiker was the most abundant species (Figure 4.2).

Non-forest mammal species detected along transects in the protected forests included blue wildebeest (*Connochaetes taurinus*), burchell's zebra (*Equus burchell*) and eland (*Taurotragus oryx*). Baboons (*Papio ursinus*) were only detected in the Hogsback forest. A variety of domestic animals (e.g., cats and dogs) and livestock (cattle, goats and sheep) were encountered in communal forests but were rare within the protected forests. The Afromontane and Coastal communal forests had a mean species abundance of 12.1 ±5.4 and 6.5 ±5.0, respectively, whilst the protected forests had a mean species abundance of 18.0 ± 7.0 (Figure 4.3). Species abundance was not statistically different between the three forest types (F= 0.6, df= 2, p= 0.1).

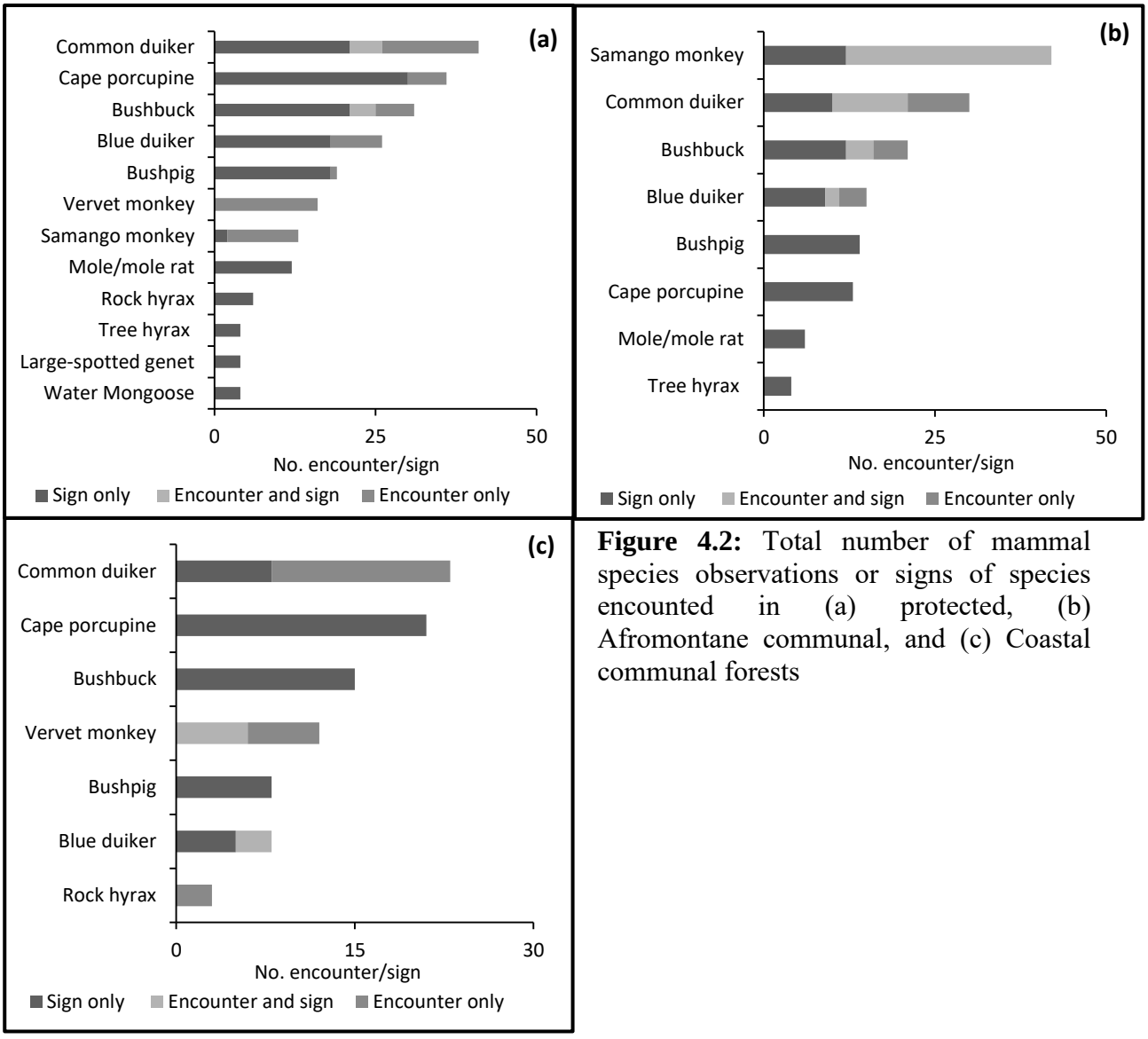


Figure 4.2: Total number of mammal species observations or signs of species encounted in (a) protected, (b) Afromontane communal, and (c) Coastal communal forests

All the forests exhibited signs of human activity, with the Coastal communal forests showing the most (Figure 4.3). Human disturbances noted in the forests were felling for settlement, agriculture, and firewood, livestock grazing, logging, bark stripping, and snaring. Anthropogenic disturbances were recorded in all transects conducted in the Afromontane and Coastal communal forests.

In the protected forests, human disturbances were significantly less than in the two communal forest types (F=26.5, df=2, p=0.04). Whist conducting the line transects 15 wire snares were located and removed in the protected forests. A further 29 snares were seen in the communal forests, but these were not removed to avoid conflict with local hunters. There was no significant association (r=0.66, p=0.08) between species richness and human disturbances in

surveyed forests. This implies that anthropogenic disturbances did not affect mammal species richness in the study area. Yet, there was a negative significant relationship between forest mammal species abundance and anthropogenic disturbances within the forests (r=-0.9, p=0.05). Suggesting a decline in the abundance of forest mammal species as human induced forest disturbances increase.

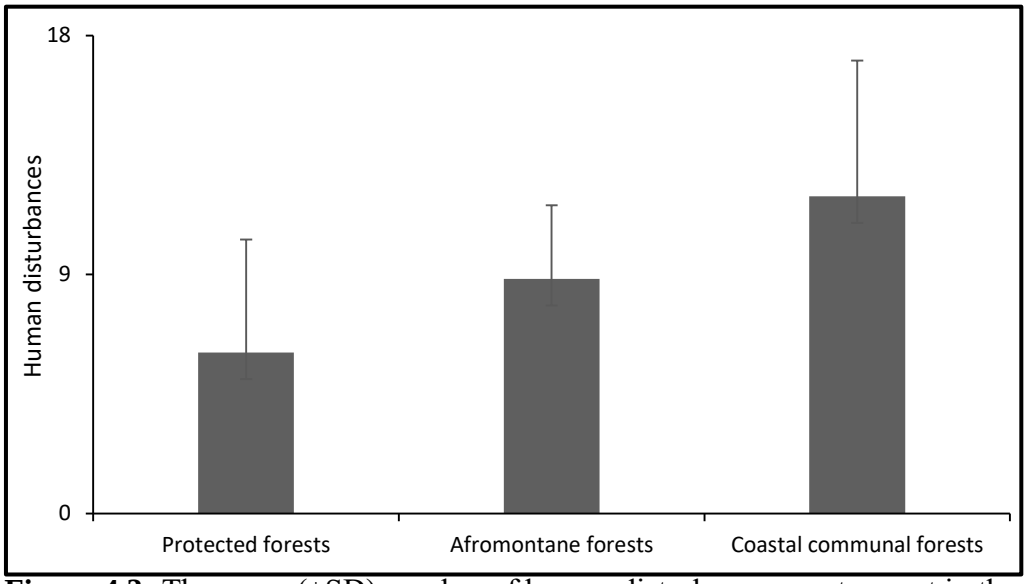


Figure 4.3: The mean (±SD) number of human disturbances per transect in the three forest types.

4.3.2 Forest mammal diversity assessed using Local Ecological Knowledge

Thirty-six percent of the interviewees were from villages around the inland Afromontane forests, and 64% were from villages adjacent to Coastal forests. In the study area 63% of the respondents mentioned that they were regular forest users and 35% attested to being hunters (all males). In each village hunters were identified by the headmen thereafter a snowball sampling approach was used until no new hunters were identified. Two percent of the interviewees were local experts from the four nature reserves in the study area (Table 4.2), there were no local experts interviewed in the Afromontane region. The age of the respondents ranged from 32 to 76 years.

Table 4.2: Demographics of respondents sampled in the villages around forests of the Eastern Cape

	No. of respondents	% of respondents
Gender		
Female	152	37
Male	263	63
Purpose		
Hunters	147	35
Regular forest users	258	63
Local experts	10	2
Village		
Boxwood	25	6.3
Guquka	41	10.3
Hala	41	10.3
Lower Gqobangco	30	7.5
Mpafane	24	6.0
Ndikana	42	10.5
Needs camp	22	5.5
Ngubencuka	39	9.8
Ntengu	34	8.5
Sicimbeni	35	8.8
Tanga	32	8.0
Xutidwele	35	8.8

The frequency of forest use differed amongst the interviewees, with 8% daily, 43% weekly, 28% fortnightly and 21% monthly. More than 90% of the regular forest users went into the forest to collect NTFPs, including firewood, medicinal plants, construction poles and wood for utensils. Others (5%) were herders who went regularly into the forests to retrieve livestock. Two percent mentioned that they went into the forest to pray and perform spiritual rituals, and 3% mentioned that they regularly passed through the forest on their way to other villages. Amongst the hunters, 36% attested to rarely hunting, 32% mentioned that they hunted irregularly, whilst 23% hunted monthly. Only 9% of the hunters mentioned that they hunted on a weekly basis. Most (86%) of the hunters from the Coastal villages mentioned that they hunted in both the communal and protected forests.

Thirty-eight percent of the respondents from the villages around the Afromontane forests were hunters and 62% were forests users. All the hunters from the villages closest to the forests confirmed the presence of all the eight mammal species found in the line transects. The hunters added three species which were undetected in the line transects, namely large-spotted genet, rock hyrax and vervet monkey. The black-backed jackal was reported by 15% of the respondents from the region and was regarded as a pest species and was generally disliked. None of the respondents from the village furthest away from Langeni forest confirmed the

presence of samango monkeys. A species richness of 12 (mean: 9.4 ± 2.2) was reported for the Afromontane forests based on LEK.

In the eight villages adjacent the Coastal forests 33% of the respondents were hunters and 63% were regular forest users. Four percent of the interviewees were local experts (Table 4.3). The local experts confirmed the presence of all 12 mammals detected in the line transects conducted in the protected forests and further mentioned the presence of caracal and black-back jackal.

Table 4.3: Species richness (mean± SD) per purpose of forest visit of the respondents from the villages at different proximities to the Coastal forests.

Purpose	% respondents	Species richness	Mean± Std dev
Hunters			
Close	20	11	8.9 ±1.7
Far	13	10	7.3 ±1.2
Regular forest users			
Close	27	9	5.9 ±1.1
Far	36	8	5.3 ±1.5
Local experts	4	14	13.4 ±0.7

The hunters from the villages closest to the Coastal forests listed more species compared to those from far villages (t= 2.8, df= 82, p= 0.002). Whilst there was no significant difference in the species richness responses given by regular forest users from villages close and further away from the Coastal forests (t= 1.6, df= 42, p= 0.11).

The multiple linear regression models fitted on the species richness responses against respondent attributes (Table 4.4) revealed an overall weak, significant correlation (r^2 = 0.04; df = 414; F = 64.68; p = 0.0009). Table 4.4 further shows that there was a significant negative association between number of species listed and distance to forest (p = 0.007), suggesting those living closer to forests reported more species. Also, there was a significant positive, association between purpose of forest visit and number of species listed ($p < 0.05$). The hunters from both the villages adjacent to the Afromontane (16.0± 5.7) and Coastal (13.0± 9.5) forests had more knowledge of species richness than the regular forest users.

Table 4.4 also shows the results of multiple linear regression models fitted on the species abundance estimates given by the interviewees (r^2= 0.02; df = 414; F = 1.19; p= 0.310). There was a significant negative, relationship between proximity to forest patch and species abundance responses (p= 0.01), suggesting that respondents from villages closer to forests had better knowledge on species abundance. There was no other significant association shown by the MLRM.

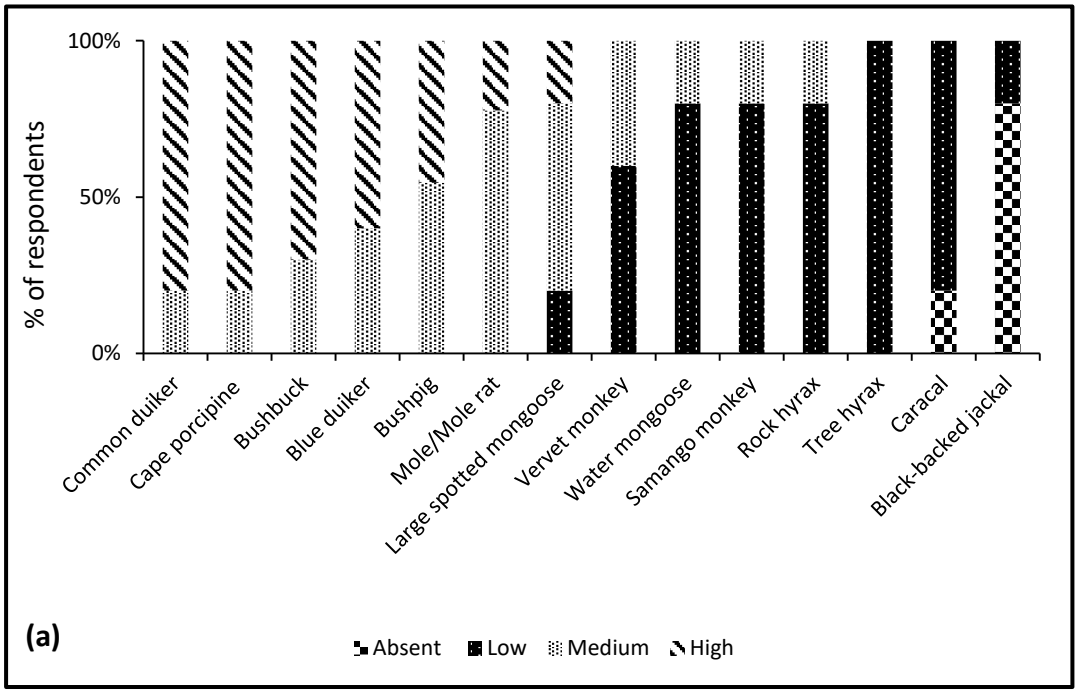
Table 4.4: Multiple linear regression model fitted on species richness and abundance reported by respondents from the villages adjacent Eastern Cape forests against different forest user predictor variables.

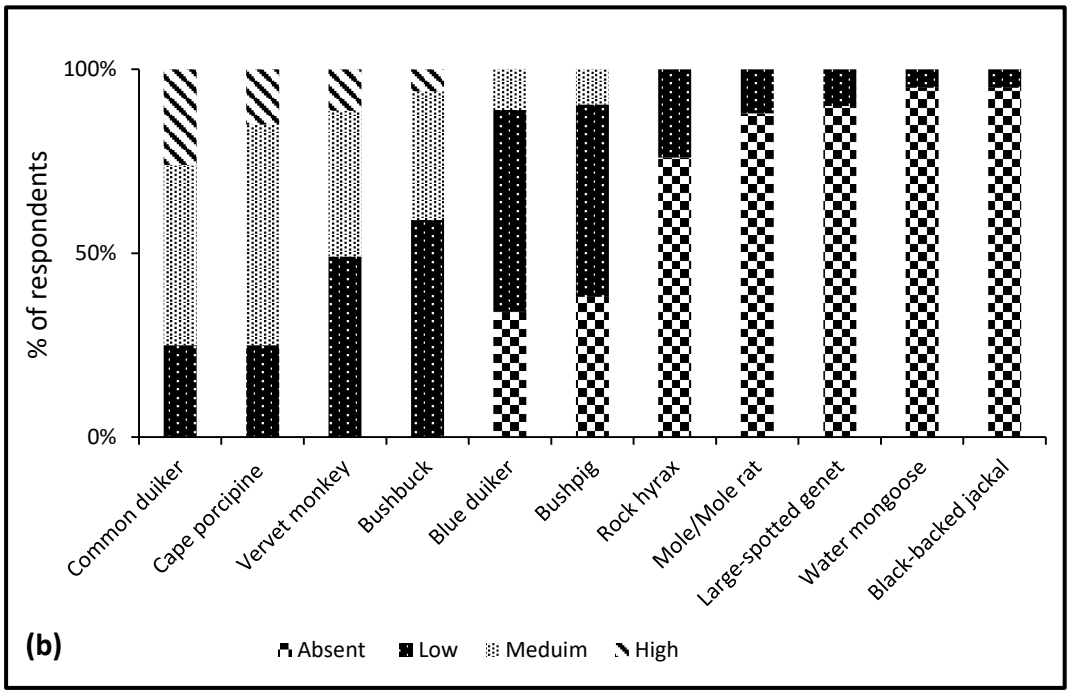
	Species richness			
Attributes	**Coefficients**	**std error**	**t-value**	**p-value**
Age	0.04	0.011	1.315	0.189
Distance to forest	**-0.065**	**0.215**	**-0.302**	**0.007**
Forest type	-0.015	0.185	-0.185	0.934
Frequency of forest visit	0.024	0.117	0.213	0.831
Gender	0.049	0.213	0.432	0.814
Purpose of forest visit	**0.049**	**0.136**	**1.361**	**0.020**
	Species abundance			
Age	0.001	0.004	0.417	0.677
Distance to forest	**-0.164**	**0.069**	**-2.364**	**0.010**
Forest type	-0.007	0.059	-0.126	0.899
Frequency of forest visit	0.015	0.037	0.392	0.695
Gender	0.036	0.068	0.528	0.597
Purpose of forest visit	0.098	0.064	1.398	0.163

Figure 4.4a shows the abundance of the forest mammal species in the protected forests as reported by the local experts (mean relative abundance: 1.7± 0.1). Common duiker, cape porcupine and bushbuck were reported to have high abundance in most of the protected forests. The local experts from Mkambati Nature Reserve reported the black-backed jackal occasionally went into the Superbowl forest. They also reported the absence of caracal within this protected forest.

The LEK surveys conducted in the eight villages adjacent to the Coastal forests revealed that most of the mammal species were either absent or had low abundance (mean relative abundance: 0.9 ±0.5) (Figure 4.4b). This confirms the results from the line transects which also indicates that most of the mammal species were in a low abundance.

Figure 4.4c shows abundance of species in the Afromontane forests as reported by the respondents residing in villages around these forests (mean relative abundance: 1.0 ±0.2). A high abundance was reported for samango monkeys, bushbuck, common duiker, blue duiker and bushpig by the respondents from the village at close proximity to Hogsback forest.


100%
50%
0%
% of respondents
Common duiker
Cape porcipine
Bushbuck
Blue duiker
Bushpig
Mole/Mole rat
Large spotted mongoose
Vervet monkey
Water mongoose
Samango monkey
Rock hyrax
Tree hyrax
Caracal
Black-backed jackal
(a)
Absent
Low
Medium
High


100%
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% of respondents
Common duiker
Cape porcipine
Vervet monkey
Bushbuck
Blue duiker
Bushpig
Rock hyrax
Mole/Mole rat
Large-spotted genet
Water mongoose
Black-backed jackal
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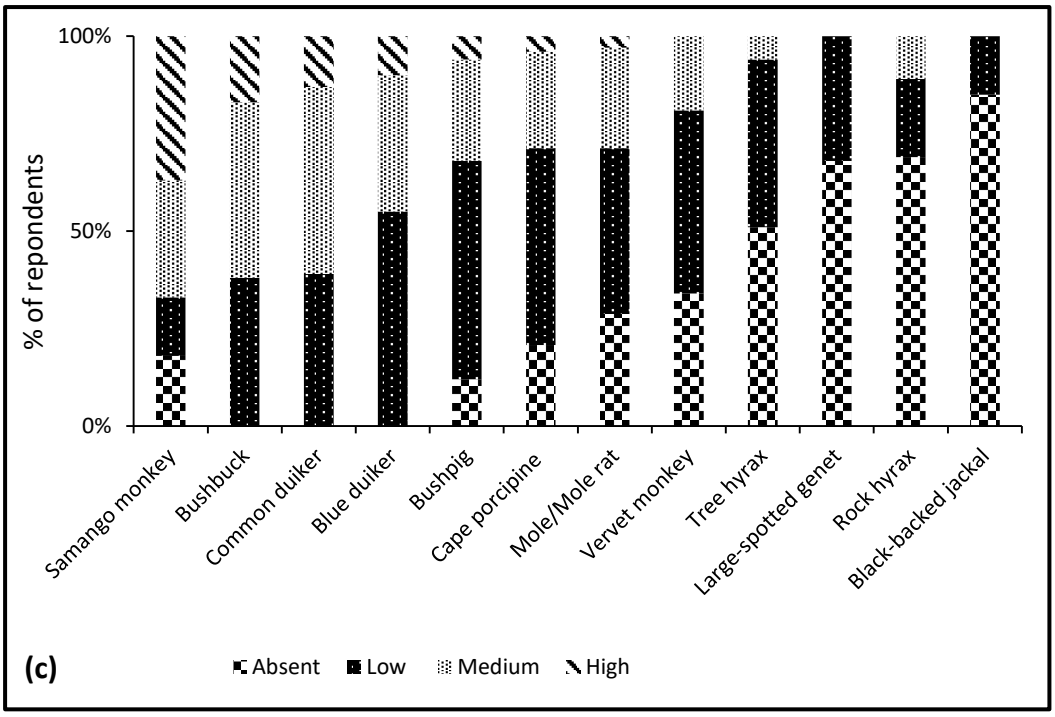

Figure 4.4: Reported abundance of each species confirmed to be present in (a) Protected, (b) Coastal communal and (c) Afromontane communal forests of the Eastern Cape

The LEK surveys reported higher species richness than the line transects (t= 6.5, df= 2, p= 0.02). In both the Afromontane and Coastal communal forests LEK reported 1.4 times more species than what was reported by the line transects. In the protected forests the LEK surveys recorded two species that were undetected during the line transect surveys.

4.3.3 Hunting pressure

In all the villages all the people who identified themselves as hunters were interviewed. Forty percent of the hunters were from villages adjacent to the Afromontane communal forests. Thirty-four percent of these hunters attested to rarely hunting, 29% hunted irregularly, 28% monthly and 9% weekly. In the 12 months prior to the study the hunters attested to harvesting 227 individuals from the 12 mammal species found in the area (Table 4.5). None of the hunters caught mole/mole rat, tree hyrax, water mongoose or large-spotted genet.

Other than the large-spotted genet and vervet monkey all the hunted species were detected in the line transects. There was a no significant relationship between the species richness in the both communal forests and hunting frequency (r=0.91, p= 0.27). The LEK surveys also confirmed the presence of all the species. There was no significant relationship between hunting frequency and the species richness responses given by the interviewees during the LEK surveys (r=0.83, p=0.22). Both the line transects and the LEK surveys revealed that samango

monkeys were the most abundant species in the Afromontane forests, yet the species was the least hunted, with only a handful of hunters reporting to have caught them. Bushbuck, common duiker, cape porcupine and bushpig were the most hunted in mammal species in the region. This was correlated with their low abundance in the line transect and LEK surveys. Similar to the species richness, there was no association between species abundance and hunting frequency (r= 0.81, p=0.09).

Proximity to hunting sites increased hunting pressure as hunters from the villages close to the forests hunted more mammal species and more individuals compared to the hunters from far villages. In the Afromontane region there was significant relationship between hunting frequency and proximity to forest (χ^2= 8.3; df= 3; p= 0.03), implying that hunters from close villages hunted more than their counterparts from far villages.

Table 4.5 also shows the number of mammal species hunted in the Coastal protected and communal forests. More species and individuals were hunted in the Coastal forests than in the Afromontane forests. There were significantly more hunters in the Coastal villages compared to the villages neighbouring the Afromontane forests (t=4.4; df= 145; p= 0.00002). Yet there was no significant difference in the offtake numbers of the Afromontane and the Coastal hunters (t= 0.7; df= 15; p= 0.5). Also, there was no significant association between hunting pressure and species richness (r=0.55, p=0.34) or abundance (r=0.88, p=0.67) in all the forests surveyed (n=10).

Table 4.5: Number of individuals harvested per species in the Afromontane and Coastal forests in the previous 12 months

		No. caught Afromontane villages			**No. caught Coastal villages**			**Total no. caught**
Common name	**Scientific name**	**Close**	**Far**	**Total**	**Close**	**Far**	**Total**	
Blue duiker	*Philantomba monticola*	14	9	23	16	8	24	47
Bushbuck	*Tragelaphus scriptus*	48	30	78	61	39	100	178
Bushpig	*Potamochoerus porcus*	21	11	32	19	11	30	62
Cape porcupine	*Hystrix africaeaustralis*	24	13	37	28	23	51	88
Common duiker	*Sylvicapra grimmia*	26	15	41	35	23	58	99
Large-spotted genet	*Genetta tigrine*	2	0	2	11	2	13	15
Rock hyrax	*Procavia capensis*	0	0	0	19	6	25	25
Samango monkey	*Cercopithecus labiatus*	4	0	4	0	0	0	4
Vervet monkey	*Cercopithecus aethiops*	8	2	10	14	7	21	31
Water mongoose	*Atilax paludinosus*	0	0	0	10	1	11	11
Total		**139**	**78**	**227**	**213**	**120**	**333**	**560**

4.4 Discussion

The study aimed to assess mammal species diversity (richness and abundance) under hunting pressure in the indigenous forests of the Eastern Cape, using line transects and LEK from inhabitants of villages adjacent to the forests. The results from both survey methods revealed higher species richness and abundance in the forests that are inside fenced protected areas than unfenced, communal forests. Conversely, more anthropogenic disturbances were detected in the communal forests than in the protected forests. Furthermore, hunting pressure had a negative impact on mammal species diversity in the Afromontane but not in the Coastal forests. The offtake numbers showed that hunting pressure increased with decreasing distance to forests as hunters from villages at close proximity from the respective forests harvested more mammal species than their counterparts from further away. The results also showed that the mammal species diversity estimates attained from line transects and LEK were significantly different, with line transects reporting fewer species in all three forest types.

Confirming my first prediction the forests within fenced protected areas in the Eastern Cape had higher mammal species richness and abundance compared to the communal forests. This confirms the findings of numerous studies globally that compared mammal species richness and abundance in protected versus unprotected areas (e.g. Carrillo et al., 2000; Magioli et al., 2021; Cooke et al., 2022; Magoulick and Liu, 2024). All the studies reported significantly more mammal species and animals per species in protected than unprotected areas. This is largely because protected areas are patrolled regularly hence had less anthropogenic disturbances. Unlike in the communal forests, where wildlife is an unmanaged common pool resource, fenced protected forests provide some security against unsustainable harvesting. The benefits of fenced protected areas have been documented in literature since their inception, with many highlighting their importance in species management and conservation (Hayward and Kerley, 2009; Ferguson and Hanks, 2012; Pekor et al., 2019; Taylor et al., 2021). Though protected areas are useful tools to combat bushmeat hunting and other anthropogenic threats to forest species, they are not immune to human disturbances (Hayward, 2009; Leaver et al., 2019). This was confirmed by both the line transects and LEK surveys, as wire snares were also detected in the protected forests. Also during LEK the surveys with hunters and local experts it was stated that some hunting does occur in the protected forests. The extensive harvesting of wild mammals and habitat destruction within the communal forests, has led to low species richness and abundance. In turn this has triggered rural hunters to cross the fence barrier and hunt in the

protected forests. The LEK surveys with local experts further showed that even though the forests within fenced protected areas also are subjected to different anthropogenic pressures, regular patrols and community engagement initiatives play a role in reducing bushmeat hunting and controlling forest destruction.

Also, as predicted, other anthropogenic disturbances including destruction of forests for agriculture, human settlement and firewood, logging, and livestock grazing were more prevalent in communal forests than the protected forests. All the respondents mentioned that even though the chiefs and headmen were responsible for the respective communal forests there was no management or rules regarding harvesting. Due to the lack of natural resource management in communal forests anyone can harvest resources or destroy a part of a forest with no repercussions. The anthropogenic activities in the forest landscape can have different consequences for the different mammal species within them (Ehlers-Smith 2016). In most cases anthropogenic activities bring changes to the forest habitat (Zungu et al., 2020), often resulting in negative impacts to several species and abundance of certain forest mammal species (Zungu, 2018; Smith et al., 2019; Oberosler et al., 2020; Zungu et al., 2020; Sosibo et al., 2022). In an assessment of how human activities affect forest mammals in the Afromontane forests of KwaZulu-Natal and the Eastern Cape, Sosibo, (2021) concluded that anthropogenic disturbances had negative behavioural and ecological consequences to certain mammal species. In Tanzania Obserosler et al. (2020) compared mammal species diversity within protected and communal forests, they confirmed that with increased human activities in the communal forests there was a decrease in forest mammal diversity. The findings of my study also found a negative correlation between forest mammal diversity and human disturbances, confirming the conclusions of the many studies conducted in the forest biome. Anthropogenic disturbances were detected in all the line transects conducted in the communal forests, whilst significantly fewer signs of disturbance were found within the protected forests. The observed disturbances were tree felling for settlement, agriculture, and firewood, livestock grazing, logging, bark stripping, and snaring.

In the year prior to the study there was no significant difference in the overall hunting pressure between the Afromontane and Coastal forests, rejecting my hypothesis even though the LEK survey with hunters revealed that more species and more individuals per species were harvested from Coastal forests compared to the Afromontane forests. In both regions there was a negative correlation between proximity to forests and hunting pressure, this suggests that the hunters

from the villages closest to the forests hunted more than the hunters from villages further away. This was also confirmed by hunter offtakes as more animals per species were harvested by hunters from close villages. In the Afromontane forests, my results showed that hunting pressure was negatively associated with species diversity, as predicted. Contrary, in the Coastal region hunting pressure did not seem to have an effect on species diversity.

Species diversity surveys are crucial in the assessment and management of mammal species populations under anthropogenic pressure (Hodgson et al., 2018, Chen et al., 2022). The efficiency of management decisions depends on species surveys and population size estimates, indicating that improvements to the data collection methods may herald better management decisions (Hodgson et al., 2018). Line transects are scientific survey methods, which provide verifiability, objectivity, and when applied correctly, accuracy and precision (Braga-Pereira et al., 2022). On the other hand, LEK arises from empirical knowledge and day-to-day practices rooted within individual views of the surrounding ecosystems which may also be driven by culture (Congretel and Pinton, 2020). Considering that the results from the two methods were different in terms of species diversity estimates suggests that conventional scientific survey methods based on direct sampling of wildlife species can be substituted and in certain circumstances, enhanced by LEK-based techniques. In accordance with my results, wildlife population estimates using mixed-methods conducted in the Brazilian Amazon forests also revealed that line transects underreported species populations and failed to report certain nocturnal and rare species (Braga-Pereira et al., 2021). The study found that the ecological knowledge of local populations in the Amazon was more accurate than years of conventional scientific monitoring of mammal species richness and abundance. Common methods used in wildlife surveys and monitoring (e.g. line transects and camera trapping) remain challenging as these methods require high logistics and financial resources, more so for long-term research conducted in remote and inaccessible terrain (Camino et al., 2020; Braga-Pereira et al., 2022).

The past few decades have seen an increase in the use of LEK-based methods in wildlife monitoring and management (Davis and Wagner, 2003; Camino et al., 2020). Indigenous communities have practiced sustainable resource management practices over centuries (Braga-Pereira et al., 2022). By integrating indigenous knowledge, conservationists and wildlife managers can adopt more sustainable approaches to resource extraction that prioritize the long-term health of ecosystems (Camino et al., 2020). LEK research focus has proceeded on the basis that livelihood reliance within specific locations results in intimate relations between

local people, the environment, and natural resources (Joa et al., 2018). The intimacy of the relationship and the dependence of the local people involved form a particular and detailed knowledge of the local environmental conditions, ecological processes, and species thereof (Magalhães et al., 2022). In a global biodiversity perspective indigenous people are seen as stewards of the world's most biodiverse regions (Fromentin et al., 2022). Their knowledge of local flora and fauna is invaluable for the conservation of wildlife and understanding their survival requirements (Fromentin et al., 2022).

Globalisation has changed urban societies this has resulted in linguistic and cultural homogenisation (McElwee et al., 2020). While there is rapid social change in urban societies, it is much slower in rural communities globally. Yet, rural communities are also accepting more urbanised lifestyles and gradually surrendering their traditional ways of living (Fromentin et al., 2022). In turn this impacts LEK as generational practices and customs that have contributed to rural knowledge for wild species and ecosystems is gradually being lost (McElwee et al., 2020). Hence, it is imperative for researchers to understand who has the relevant LEK, in order to get meaningful results. In my study the levels of LEK differed, with hunters showing more knowledge of forest mammal species than the regular forest users. This is greatly due to the time spent in the forest and the species they caught. In a complex social-ecological system such as bushmeat hunting LEK plays an important role in the management and conservation of mammal species. This suggests that if hunting is conducted in a sustainable manner, hunters are potentially the most relevant people to preserve LEK.

Using data acquired from traditional scientific line transect surveys and LEK, I compared species richness and abundance under hunting pressure in three forest types of the Eastern Cape. The study demonstrates the importance of mixed-methods research in wildlife conservation and sustainable natural resource use. Given that interviews with hunters, regular forest users and local experts enhance sampling effort and reduce financial costs, LEK based methods may overcome the lack of resources to continue with assessments, which is usually a major constraint in conservation research and environmental projects. LEK offers a powerful tool for tackling the complex social ecological challenges we are currently faced with. By acknowledging the value of local wisdom, respecting their rights and traditions collaboration between indigenous knowledge holders and modern ecologists, long-term sustainability can be achieved. Embracing LEK is not just ecologically imperative; it is a step towards a more inclusive and sustainable future for all.

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Chapter 5

Assessing the sustainability of bushmeat hunting in the forests of the Eastern Cape

Picture showing hunters from a village in the Eastern Cape, showcasing their catch and hunting dogs (Picture shared by an interviewed hunter).

5.1 Introduction

The hunting of terrestrial wildlife species for consumption and income is a reality in many rural settings around the world (Brashares et al., 2011; Fa et al., 2022). Research conducted in the last few decades suggests that over five million tons of bushmeat are harvested annually in the Amazon and Congo basins alone (Fa et al., 2002; Nasi et al., 2011; Cawthorn et al., 2015; Lee et al., 2020). These figures have brought bushmeat into the spotlight due to the widely held assumption that hunting in most tropical forest regions is unsustainable and that overhunting leads to "empty" forests (Redford, 1992; Fa et al., 2002; Fa and Brown, 2009; Abernethy et al., 2013; Ripple et al. 2016, Wilkie et al., 2016). However, accurately measuring the sustainability

of bushmeat hunting is challenging due to the dynamic nature of hunting systems (Weinbaum et al., 2013; Shaffer et al., 2018; Ingram et al. 2021).

In dynamic social-ecological systems, both temporal and spatial scales significantly influence sustainability outcomes. Short-term changes, such as seasonal resource fluctuations, often differ from long-term dynamics like ecological regeneration (Cumming et al., 2022; Biggs et al., 2021). Spatial scales add complexity, as local interactions may not align with regional or global patterns (Reyers et al., 2023). Additionally, supply-demand curves, including elasticity concepts, help explain how market forces and resource availability shape harvesting behaviours (Milner-Gulland & Rowcliffe, 2007; Cooney et al., 2020). These frameworks provide critical context for understanding the complexities of sustainability (Fischer et al., 2022).

Various methods have been proposed to estimate the rate of extraction from wildlife populations by hunters (Weinbaum et al., 2013; Van Vliet, Fa, and Nasi, 2015; Shaffer et al., 2017). One widely used is Robinson and Redford's (1991) production model, which relies on static indices to evaluate the sustainability of wildlife harvesting. Through the common use of such models many researchers have concluded that most bushmeat hunting in the tropics is unsustainable (e.g. Robinson and Bennett, 2004; Van Vliet and Nasi, 2008; Van Vliet et al., 2015), even though recent studies still present hunting in tropical areas as the primary source of protein and a key component of local livelihoods (Evans et al., 2020; Nasi et al., 2021 Groom et al., 2023). Moreover, several studies have commented that the indicators most commonly used to evaluate the sustainability of wildlife hunting do not perform well under realistic conditions, like the changes in prey mortality or birth rates (Van Vliet and Nasi, 2008; Zapata-Rios et al., 2009; Van Vliet et al., 2016).

The connections between hunting and livelihoods, health, culture, and the local economy are not fully understood and are often overlooked in sustainability analyses (Nasi et al., 2008; Di Mini et al., 2021). Both quantitative and integrative approaches are required to fully comprehend these relationships (Nasi, 2008; Sirén, 2015). Simple models that only compare hunter catch with maximum wildlife population production are not sufficient and can lead to undesired outcomes such as inaccurate conclusions about sustainability (Weinbaum et al., 2013; Dobson et al., 2019; Riddle et al., 2022). Hunting systems are influenced by a wide range of drivers, including social, ecological, economic, and governance (Millner-Gulland, 2012; Van Vliet and Nasi, 2015; Rogan et al., 2018; Torres et al., 2021). The social-ecological context in which hunting occurs must be considered at different scales to understand its sustainability

(Van Vliet et al; 2016). It is important to recognize that hunting systems are complex social-ecological systems that are not predictable, deterministic or mechanistic, but are process-dependent, natural systems with feedback loops at multiple levels (Van Vliet and Nasi, 2015). As a result, bushmeat hunting should be seen as a complex social-ecological system, where what is vulnerable in one place may not be vulnerable (or vulnerable in the same way) in another and that vulnerability changes through time (Cawthorn and Hoffman, 2015; Brodie and Fragoso, 2021).

To adequately assess the sustainability of bushmeat hunting in a specific context, the focus should not only be on the animal species populations, but on the social-ecological system as a whole (Van Velden et al., 2020). In simple biological models the only social parameter accounted for is the amount of hunting offtake (Van Vliet et al., 2015). The sustainability of hunting does not rely solely on wildlife availability, but also on social elements of this complex system, which goes beyond hunting offtake levels (Rogan et al., 2018; Torres et al., 2021). Hunting and hunting patterns are indeed highly influenced by a range of social drivers that influence hunter decision-making. The sustainability of bushmeat hunting is intimately related to the temporal and spatial variation of hunter offtake, which are determined by a combination of social drivers, (Van Velden et al., 2020), availability of bushmeat markets (Allebone-Webb et al., 2011; Van Gils et al., 2019), land use changes (Iwaruma et al., 2013; Deith, 2022), changing livelihood opportunities (Coad et al., 2013; Van Vliet et al., 2015; Van Gils et al., 2019), and household demographics (Foerster et al., 2012; Nuno et al. 2013; Van Velden et al., 2020).

The need to incorporate complexity and stakeholder knowledge has led to the development of various quantitative and semi-quantitative methods for assessing the sustainability of bushmeat hunting (Nyaki et al., 2014; Van Velden et al., 2020). This shift moves away from relying solely on a single indicator, such as maximum sustainable yield (MSY), toward a more comprehensive approach that uses multiple indicators across different levels of the social-ecological system (SES) (Van Velden et al., 2020). These indicators collectively reveal trends over time and provide a more holistic measure of sustainability. These approaches include participatory hunter surveys to gain insights on the socio-demographics of hunters, current and past species offtake and other important parameters that may influence the sustainability of hunting (Robinson and Bennet, 2000; Dobson et al., 2019). Several other studies investigating the sustainability of wildlife harvesting have measured species composition of bushmeat in local markets (Cowlishaw et al., 2005; Allebone-Webb et al., 2011; Sackey et al., 2023);

changes in hunter catch per unit effort (CPUE) (Crookes and Blignaut, 2019; Bodmer et al., 2024) and habitat-specific species depletion using local ecological knowledge (LEK) (Bitanyi et al., 2012; Van Velden et al., 2020; Foya et al., 2023).

Participatory bushmeat hunting research has formed the basis of much of what we know about bushmeat hunting and use (e.g. Mfunda and Røskaft, 2010; Wright and Priston, 2010; Van Velden et al., 2020; Stone and Stone; 2022). This approach has provided answers to many of the questions concerning the use and harvesting of bushmeat (Froese, 2023). A few studies have combined participatory research methods with estimates of wildlife species densities, abundance and offtake to assess the sustainability of hunting (e.g. Kümpel et al., 2009; Van Vliet and Nasi, 2015; Riddell et al., 2022). For example, Riddell et al. (2022) combined offtake and hunter participatory data to assess the sustainability of hunting in tropical forests in the Republic of Congo. Results from both survey methods revealed that bushmeat harvesting was unsustainable in the region. Using participatory hunter interviews and hunter offtake data Kümpel et al. (2009) concluded that changes in prey profiles and CPUE may be the most accurate indicators of actual sustainability. These studies highlight the importance of using mixed-methods and triangulation to assess the sustainability of complex social-ecological systems like bushmeat hunting.

Subsistence bushmeat hunting in South Africa has largely been under-researched though the practice is widespread (Martins and Shackleton, 2019). Martins and Shackleton (2019) also observed that research has focused on trophy hunting on privately-owned hunting ranches (e.g. Taylor et al., 2016; Saayman et al., 2018; Parker et al., 2020) and the poaching of charismatic species like rhinoceros and elephant from national and provincial parks (e.g. Montesh, 2013; Büscher and Ramutsindela, 2016; Le Roex et al., 2020; Nhleko et al., 2022). This has left a gap in knowledge on the rural and community-based hunting occurring in communal and private land outside protected areas. The past decade or so has seen more research on bushmeat hunting in the different landscapes around the country (e.g. White, 2004; Hayward, 2009; Shackleton et al., 2007; Grey-Ross et al., 2010; Kaschula and Shackleton, 2012; Manqele et al., 2018; Van Velden et al., 2018; Young et al., 2018; Martins and Shackleton, 2019; Nieman et al., 2019; Kendon et al., 2022; Sosibo et al., 2022), with research acknowledging the importance of bushmeat hunting and use in both rural and semi-urban areas of the country. Yet there has been no study that has explicitly assessed the sustainability of subsistence bushmeat hunting on either communal or privately owned land in South Africa.

This novel study aimed to assess the sustainability of bushmeat hunting by rural, subsistence hunters in the forests of the Eastern Cape using a mixed-methods approach. Here I use social and ecological methods to gain insights on the sustainability of bushmeat hunting in subtropical forests. Hunter participatory interviews were used to assess hunting practices, and line transects were employed to determine the density of mammals in the forests of the Eastern Cape. The overall hypothesis of this research is that bushmeat hunting will be unsustainable in the communal forests of the Eastern Cape. To test this hypothesis, I pose the following hypotheses: (a) the species density estimates from communal forests will be less than that from protected forests and density estimates reported in the literature, (b) the most hunted mammal species will exceed the maximum percentage for sustainable offtake for medium-sized species and the sustainable percentage of biomass offtake, (c) the hunter participatory interviews will reveal a decline in CPUE and harvest rates in the 10 years prior to the study.

5.2 Materials and methods

5.2.1 Study area

See Chapter 1

5.2.2 Site selection

See Chapter 1

5.2.3 Survey methods

After choosing sites, I made pilot visits to each of the 12 villages to discuss the proposed project with the village chief or headman. I sought their permission to conduct the research and to identify known hunters in each village. To gather data on hunting practices, I conducted, semi-structured interviews with hunters from the 12 villages. During the interviews, I collected qualitative data on (a) the distance travelled to hunting sites, (b) time spent hunting, (c) frequency of hunting, and (d) mammal species harvested in the 12 months prior to the study. The data gathered from the hunter interviews enabled me to characterize the catch per unit effort (CPUE), harvest rates, hunting frequency, and describe hunter preferences. To gain insights on changes in hunting patterns and also to assess whether the hunters thought bushmeat hunting was sustainable or not, questions relating to trends in CPUE, harvest rates and hunting frequency over the past 10 years were also posed.

Initial respondents were identified by the chiefs or headmen in each village. Using a snowball sampling method the initial respondents helped in identifying other hunters who could be interviewed. Between September and November 2020, 147 semi-structured interviews were conducted. These individuals were the only ones who attested to hunting in the study areas. Prior to each interview, the respondents were read an informed consent letter, which was explained to them, and then signed. They were informed that they could stop the interview at any point if they wished to do so. Each interview took approximately an hour to complete. The interview protocol was approved by the human ethics committee of Rhodes University (Ethics no. 2019-1065-3178). All interviews were conducted in isiXhosa and later translated into English. Great care was taken to avoid leading questions.

Furthermore, an inventory of hunted mammal densities in the area was conducted through ecological field surveys using line transects (see Chapter 4 for detailed methodology). Species density was calculated by dividing the number of observed individuals per species by the total distance walked in the line transects. The survey provided information on the density of mammal species in each of the hunted forests. According to Robinson (2000), the maximum percentage for sustainable offtake for medium-sized mammal species varies from 5- 25% of the density of the local population, with the lowest sustainable offtake corresponding to the largest species. Also, the sustainable biomass offtake ranges from 5- 30% of the biomass of the species population (Robinson and Bennett, 2004). The density estimates obtained from the line transects and data collected from hunter interviews were used to determine the sustainability of hunting in the forests of the Eastern Cape. To triangulate the results, I also compared the density estimates of each of the commonly hunted mammal species to the densities reported in literature for each species from different biomes in South Africa.

5.2.4 Data analysis

All data collected from the hunters and from the line transects was entered into Microsoft Excel for descriptive analysis. The per capita harvest rate was taken as the mean (±SD) of the reported harvest by the hunters. CPUE was taken as the quotient of the number of animals caught by each hunter and the number of hours spent hunting in the forest. A t-test was used to compare the distance travelled by hunters from near and far villages to the hunting sites. The Pearson's rank correlation coefficient was used to examine the relationship between CPUE and different hunter variables (e.g. distance travelled to hunting site and time spent hunting) as an indication of mammal species depletion. Assuming normality of residuals and homoscedasticity of errors,

I employed a Multiple Linear Regression Model (MLRM) to determine correlations between species densities and number of individuals harvested per species. These assumptions allowed for the application of MLRM, ensuring that the model's estimations are valid and unbiased. All statistical analysis was conducted in R Environment version 4.1.3.

5.3 Results

5.3.1 Mammal species offtake, density and biomass

All 147 hunters confirmed that they had hunted mammal species from their local forest in the 12 months prior to the study. Ten forest mammal species were harvested amongst 560 prey individuals in the year prior to the study (Table 5.1), which translates to an estimated annual harvest rate of 3.8 ±0.4 prey items per hunter per year. The hunters from villages close to the forests harvested significantly more prey individuals than hunters from villages further away (t= 8.8; df= 8; p= 0.0005).

Table 5.1: Total number of individuals per species harvested by the 147 hunters in the 12 months prior to the study

Common name	Scientific name	Close villages	Far villages	Total
Blue duiker	*Philantomba monticola*	30	17	47
Bushbuck	*Tragelaphus scriptus*	109	69	178
Bushpig	*Potamochoerus porcus*	40	22	62
Cape porcupine	*Hystrix africaeaustralis*	52	36	88
Common duiker	*Sylvicapra grimmia*	61	38	99
Large-spotted genet	*Genetta tigrine*	13	2	15
Rock hyrax	*Procavia capensis*	19	6	25
Samango monkey	*Cercopithecus labiatus*	4	0	4
Vervet monkey	*Cercopithecus aethiops*	22	9	31
Water mongoose	*Atilax paludinosus*	10	1	11
Total		**360**	**200**	**560**
Mean per hunter		**4.2±0.2**	**3.3±0.2**	**3.8±0.4**

Table 5.2 shows that hunters from villages further away from forests (10.4±1.6 km) travelled significantly greater distances (t= 3.5, df= 139, p< 0.05) than hunters from close villages (5.1±0.8 km). All the hunters mentioned that on a hunting day they started hunting before sunrise, with 41% hunting until dusk and 59% hunting until midday or early afternoon. There was no significant difference (t= 0.2, df= 139, p= 0.4) in the time per day spent hunting between the hunters from close (9.1±3.0 hr) and far villages (9.2±3.0 hr).

Table 5.2: Number of hunters from each of the surveyed villages in the Eastern Cape (villages closer to forests marked with *)

Forest	Village	No. Hunters	Average distance travelled (km)	Average time spent hunting (hr)	Average CPUE (animals /hunting trip)
Hogsback	Hala*	20	4.8±1.4	7.5±2.7	0.5±0.2
	Guquka	20	8.9±0.7	7.2±2.5	0.3±0.1
Langeni	Mpafane*	12	5.2±1.1	9.0±3.1	0.7±0.2
	Lower gqobonco	6	10.0±2.4	10.0±3.1	0.5±0.2
East London	Boxwood*	8	3.5±1.3	8.3±3.1	0.8±0.2
	Needs camp	6	11.9±1.1	9.0±3.0	0.6±0.3
Hluleka	Xuthidwele*	18	3.2±0.9	9.2±3.1	0.4±0.2
	Ntengu	10	12.1±2.1	10.2±2.9	0.3±0.1
Silaka	Sicambeni*	14	4.2±0.8	11.2±7.2	0.4±0.1
	Ndikana	9	11.3±1.5	10.1±3.0	0.4±0.2
Mkambathi	Tanga*	14	4.0±1.4	8.8±3.1	0.4±0.2
	Ngubencuka	10	10.9±1.2	9.0±3.2	0.5±0.2
Total/Mean		**147**	**7.1±2.9**	**9.1±3.0**	**0.5±0.2**

There was a significant positive, albeit weak correlation between time spent hunting and CPUE (Pearson $r_{(140)}$= 0.2, p= 0.0007), showing that the more time hunters spent hunting the more prey they caught. Contrary, there was no significant association between the distance travelled to the respective hunting sites and CPUE (Pearson $r_{(140)}$= 0.3, p= 0.74). The most commonly caught species were bushbuck (n= 178), common duiker (n= 99), cape porcupine (n= 88) and bushpig (n= 62). The multiple linear regression fitted on mammal species density and the number of individuals harvested per species revealed no significant relationship (r^2= 0.24, df= 9, p= 0.1) (Figure 5.133).

Table 5.3 presents density estimates for the five most hunted mammal species in different landscapes around South Africa. Results from various parts of the country show that the density of mammals varies from 0.3 individuals/km^2 for bushpig to 17 individuals/km^2 for common duiker. The density estimates for the five mammal species in the communal forests in my study were significantly (t=2.6, df=4, p=0.03) lower than the density estimates in the literature.

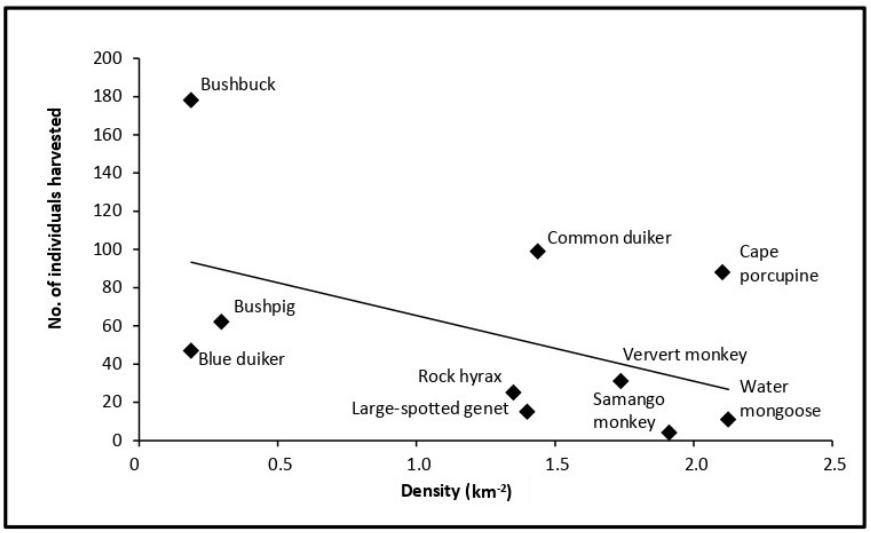

Figure 5.1: Linear regression of the density of hunted species versus the number of individuals hunted per species

Yet, there was no significant difference (t=1.9, df= 4, p=0.1) in density estimates between those in the literature and those obtained in my study in the protected areas. Also, the density estimates of the species in the protected forests was significantly (t=6.8, df= 4, p=0.0001) higher than in the communal forests in the region.

The line transects detected a total of 926 individuals of the 10 species. Sightings per species ranged from six (large spotted genet and water mongoose) to 170 (common duiker). The minimum recommended sample size for obtaining robust density estimates of 20 detection events per species (Peres, 1999) was attained for all but two of the 10 species. As reported by the hunters, the mean estimated density of the harvested mammal species was 4.2±0.4 animals/km^2 and the mean harvested biomass was 16 100±2 665 kg in the forests of the Eastern Cape.

Table 5.3: Comparison of density estimates in the different ecosystems in South Africa for the five most hunted mammal species

Species	Density (individuals /km^2)	Location and vegetation	Tenure	Comments	Density from survey of EC forests (individuals/km^2)		Reference
					Protected	Communal	
Blue duiker	1-2	Garden Route National Park, forests	Protected	Higher densities in other regions in the continent post 2000	1.7±0.4	0.3±0.1	Seydack et al. (1998); Venter et al. (2016)
Bushbuck	3-10	KZN, thicket and Coastal bushveld–grassland	Protected	-	3.4±1.1	0.5±0.2	Skinner and Chimimba (2005); Coates and Downs (2007)
Bushpig	0.3-0.5	Southern Cape forests	Protected	-	2.0±0.6	0.3±0.1	Seydack, (2013); Venter et al. (2016)
Cape porcupine	8	Bokkeveld Plateau, Northern Cape	Farm	-	2.0±0.8	0	Bragg et al. (2005)
Common duiker	0.4-17	Dunefield and Riparian woodland, Addo Elephant Park	Protected	0.4 individuals per km^2 in Dunefield and 17 individuals km^{-2} in Riparian woodland	1.8±0.3	0.4±0.2	Boshoff et al. (2002); Venter et al. (2016)

The impact of bushmeat hunting on the populations of the five most commonly harvested mammal species shows that the annual offtake accounts for 23–63% of the local population densities (Table 5.4). The maximum percentage for sustainable offtake for medium-sized mammal species varies from 5- 25% of the density of the local population, according to species and study sites, with the lowest sustainable offtake corresponding to the largest species (see review in Robinson, 2000). This suggests unsustainable offtake for all the five most hunted species in the region. The number of harvested bushbuck biomass exceeded the total biomass counted in the communal forests, further confirming that hunting pressure drives some animals to migrate to adjacent protected forests.

Table 5.4: Species density, harvest rate and biomass of commonly hunted mammal species in the forests of the Eastern Cape

Species	Total density (individuals /km^2)	Average number of animals harvested (±SD)	Total biomass of counted individuals (kg)	Harvested biomass (kg)	Sustainability
Blue duiker	1.3 ± 1.4	0.3± 0.1	853	385	Unsustainable
Bushbuck	1.9± 1.4	1.2± 0.6	7 038	8 330	Unsustainable
Bushpig	1.4± 1.3	0.4± 0.2	7 134	3 950	Unsustainable
Cape porcupine	1.9± 0.2	0.6± 0.3	2 349	1 487	Unsustainable
Common duiker	2.1± 1.9	0.7± 0.3	2 686	1 564	Unsustainable

Table 5.4 also shows that the average harvested annual biomass of the five mostly hunted mammal species in all the surveyed forests was 3 143± 3 177 kg. The harvested annual biomass accounts for 45 -100% of the total biomass for each species. This further indicates unstainable offtake of mammal species in the forests of the Eastern Cape as sustainable offtake ranges from 5 - 30% of the biomass (Robinson and Bennett, 2004).

5.3.2 Hunter perceptions of sustainability

All the hunters reported a decline in the density and abundance of the five most hunted species over the past 10 years in the forests that they frequent. Thirty-five percent of hunters from the Coastal villages reported that in the last 2 -3 years they had not caught cape porcupine in Xuthidwele and Tyityane forests. The hunters from the villages around Hogsback forest mentioned that the number of samango monkeys had increased in the past 10 years. Whilst 78% of the hunters from the villages adjacent Coastal forests reported an increase in vervet monkeys. They mentioned that this was because they did not particularly hunt the primate species as they did not enjoy the meat, and it was difficult to catch them. Ninety-eight percent of the hunters mentioned that their harvesting rates had decreased over the past 10 years. The two percent that mentioned that their harvest had not decreased were hunters for the villages near the Hogsback forest. Slightly more than half (59%) of the hunters revealed that their harvest rates had decreased by more than 50%, whilst 38% stated that their harvest declined by less than 50% and only 3% stated that their harvests had not declined (Figure 5.3). Hunters attributed the decline to anthropogenic forest disturbances, with all noting that forests were declining for human settlement and agricultural practices. Sixty-two percent also stated that overharvesting had contributed to their deceased hunting success. Others reported unemployment as an important factor leading to increasing numbers of hunters in their respective villages. Some of the hunters mentioned that the decreased harvest rates were a

consequence of human avoidance by some of the species they mostly caught in the past. One of the hunters said:

"*There is a lot of human activity in and around the forest, now the animals hide and only come out at night or go into the nature reserve."*

When asked whether their time hunting in the forests had decreased or increased in the past 10 years all mentioned that they spent more time either searching for animals or it took longer for their snares to catch prey. Thirty-two percent of the hunters stated that they sometimes went home empty-handed after a spending a whole day in the forest. Over a third (35%) of the hunters mentioned that their frequency of hunting had deceased over the past 10 years as they did not catch as much prey any more. These hunters also mentioned that although they enjoyed hunting it was not as rewarding as it was in previous years. The hunters from villages adjacent to Coastal forests reported an increase in hunting within local protected areas due to not catching sufficient prey in the communal forests.

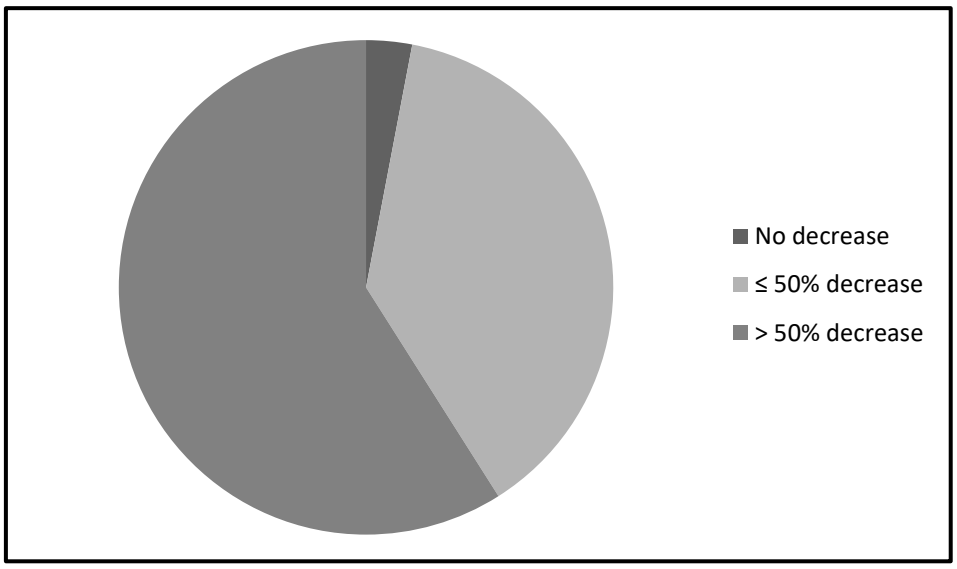

Figure 5.2: Hunter responses to whether harvest rates had decreased in the past 10 years

5.4 Discussion

This study aimed to determine the sustainability of bushmeat hunting in the communal forests of the Eastern Cape province. Using a combination of social and ecological approaches I was able to gain insights on how forest mammal species offtake affected species density in the

region. The use of traditional methods such as population growth models and once-off biological indicators to evaluate the sustainability of bushmeat harvesting overlook the links between hunting and livelihoods, health, culture, and the local economy (Nasi et al., 2008; Van Vliet and Mbazza, 2011; Di Mini et al., 2021; Koné et al., 2023). Here I view bushmeat hunting as complex social-ecological systems and use mixed social-ecological methods to make inferences on bushmeat hunting sustainability in the Eastern Cape that include both the hunted species and the social dynamics of the hunter.

Confirming the overall hypothesis of the study my results revealed unsustainable bushmeat hunting in the communal forests of the Eastern Cape. The subtropical, unfenced forests in South Africa are often state property, which almost always lacks law enforcement, while traditional authority is commonly undermined (Grundy et al., 2004). This leaves resource harvesting such as bushmeat hunting a free for all with limited enforcement of any restrictions on harvesting. In this context bushmeat hunting is a complex common-pool resource predicament (Rickenbach, 2015; Marrocoli et al., 2018; Mavah et al., 2022). In the tropical forests Marrocoli et al. (2018) conducted an experiment of common-pool resource exploitation framed around bushmeat hunting. They show that in the absence of state law enforcement, community-based natural resource management and participatory monitoring systems are important in promoting the sustainable use of a common-pool resource such as bushmeat. They conclude that in a complex social-ecological system, such as bushmeat hunting, hunter self-monitoring could be a useful tool to initiate behavioural changes as well as promoting sustainable use of wild meat. With very minimal state law enforcement, absent community wildlife management institutions and no hunter participatory monitoring in most of the forests outside fenced protected areas in the Eastern Cape, the harvesting of bushmeat is an unmanaged, uncontrolled and mostly unsustainable common-pool resource.

There was strong support for the first hypothesis, namely that mammal species densities in the communal forests will be less than those in the protected forests and forest mammal density estimates reported in the literature. The ecological surveys revealed significantly higher species densities in the protected forests than communal forests for all the mammal species. Also, the mammal density estimates for the five most hunted mammal species in the communal forests were also significantly less than what was reported in the literature for each species. In a comparison of mammal species densities between forests under different hunting pressures in Tanzania, Topp-Jørgensen et al. (2009) also found decreased species densities in the intensely

hunted forest compared to the forest with little hunting pressure. The study concluded that hunting reduces the density of wildlife populations in severely hunted landscapes. Also, in a literature review on the impact of bushmeat hunting on mammal species in the heavily harvested African moist tropical forests, Fa and Brown (2009) found that mammals were the leading source of bushmeat, with ungulates and rodents making up the highest proportion of biomass extracted. They further mentioned that mammal densities in the region are declining at rapid rates as they are being harvested in an unprecedented scale. This was also echoed by Hegerl et al (2017) in their assessment of bushmeat hunting on mammal species in two ecologically similar forests with different protection status in Tanzania. They revealed that the mammal community in the least protected forest was degraded in abundance and richness relative to the protected forest. Mammal species density was 40% lower in the less protected forest and the occupancy of most species was also reduced significantly. The study concluded that ineffective wildlife management, with virtually absent law enforcement, leads to uncontrolled illegal hunting, which in turn has significant impacts on the mammal fauna in biodiversity rich areas, which are often important sites for conservation.

My results show that the hunters in the villages of the Eastern Cape mostly hunted large forest mammals, i.e. bushbuck, common duiker, cape porcupine, bushpig and blue duiker. Offtake of all five of the most hunted mammal species exceeded both the maximum percentage for sustainable offtake and the sustainable percentage of biomass offtake for medium-sized mammal species. My evaluation of the impact of hunting on the populations of the five most hunted species in the communal forests of the Eastern Cape shows that the annual offtake accounted for over double the recommended offtake of the local population densities (Robinson, 2000). Furthermore, the harvested annual biomass was almost five times more than the sustainable biomass offtake suggested in Robinson and Bennett (2004). Brugiere and Magassouba (2009) also used the maximum percentage for sustainable offtake to assess the patterns and sustainability of bushmeat trade in the Niger National Park, Republic of Guinea. Based on this they reported unsustainable offtake for three species of ungulates which exceeded the maximum percentage for sustainable offtake. On the basis of their findings the park developed a wildlife management agreement with hunters and bushmeat traders, which involved limiting of hunting according to the abundance of these ungulates.

The hunter participatory interviews provided strong evidence for the third hypothesis of a decline in CPUE and harvest rates in the 10 years prior to the study. The participatory

techniques with hunters from the respective villages surrounding the indigenous forests of the Eastern Cape supported the results of the ecological surveys; i.e. the hunters reported declining mammal species densities in all the surveyed communal forests. The hunters provided in-depth data on changes CPUE in the 10 years before the current study. Hunters stated that they spent longer periods hunting and caught less prey than they did 10 years ago. Rist et al. (2010) assessed the effectiveness of using hunter reports of CPUE as a monitoring tool for sustainable bushmeat hunting in a village in Rio Muni, Equatorial Guinea. They found that hunter participatory techniques were just as effective, if not more efficient than ecological monitoring. The study concluded that hunter participatory techniques can offer an accurate, cost-effective and sufficiently powerful method to monitor the status of wildlife species. On the basis of their findings they recommend that conservation practitioners should consider resource-user based monitoring techniques for the assessment of sustainable natural resource use. Further supporting the findings of the current study, in northern Congo Riddell et al. (2022) used hunter participatory data to assess the sustainability of a hunting system in an area under commercial development. They show how participatory hunter surveys can be used to show changes in prey populations and changes in hunting strategies, therefore improving the effectiveness of long-term offtake datasets to assess sustainability of hunting.

The hunter participatory interviews provided insights on how low CPUE and decreased hunting rates resulted in changes in hunting strategies, behaviour and attitudes towards hunting. The hunters reported a decline of all the mammal species in the communal forests in the 10 years prior to the study, with some reporting local extinction of certain species. Hunters reported foraging for hours in communal forests and not catching any prey, hence some hunters from the Coastal villages attested to increasingly hunting in the neighbouring protected forests, risking prosecution as there were greater chances of catching prey. Some of the hunters mentioned that they had decreased their hunting frequencies as hunting was not worthwhile anymore. Coad et al. (2013) assessed the social and ecological changes of the hunting systems in two neighbouring villages in Gabon over a period of 10 years. Contrary to my findings, the hunters in the study maintained their CPUE as there were no significant changes in the species composition of their catch and offtake. Also, their results did not indicate depletion of the biomass of prey populations. However, they mentioned that during the survey the hunters increased the distance from the villages at which they laid their traps and changed their hunting strategies from traps to guns which may have been an indication of prey depletion. Similar to the current study, in Sendje village, Equatorial Guinea Gill et al. (2012) found that with

increasing hunting pressure over a 10-year period, hunter CPUE decreased as the prey species decreased significantly. They also found that the out-migration of hunters to other areas of the country for employment led to declines in hunter total offtake as there were fewer hunters. The study concluded that if the demand for bushmeat remains high in urban areas hunting will continue at unsustainable levels in the region. Yet, external economic development like job creation can strongly affect the level of hunting in a rural community.

The study further shows that hunters from villages close to the forests harvested more animals than their counterparts from villages further away. Studies that assessed bushmeat hunting pressure using spatially-based modelling suggest that spatial factors such as distance to hunting area, the size of the surrounding villages and hunter movements are important determinants of bushmeat harvest sustainability (e.g. Van Vliet et al., 2010; Ziegler et al., 2019; Duporge et al., 2020; Deith and Brodie, 2020; Loveridge et al., 2020; Brodie and Fragoso, 2021; Deith, 2022). Van Vliet et al. (2010) assessed the small-scale heterogeneity of prey and hunter distributions on the sustainability of bushmeat hunting in a village in Gabon. They revealed that the spatial distribution of the prey population relative to the spatial distribution of hunting effort is a crucial determinant of the sustainability of a hunting system. Their results showed that the hunting areas closer to the village showed decreased mammal species than the unhunted and seasonally hunted areas further away. They concluded that the impact of hunting on prey populations depended on the spatial heterogeneity of hunting and hunting pressure. Also, the existence of areas hunted throughout the year, areas hunted only during certain seasons, and unhunted areas contributed to the sustainability of the system. To assess hunting pressure in the rainforests across Malaysian Borneo, Deith and Brodie (2020) mapped hunter movements and established that incorporating fine-scale spatial heterogeneity to simple models can be a powerful tool for understanding and predicting widespread threats to biodiversity. Hence, variables such as spatial distribution of hunting villages, spatial variation in wild meat hunting effort, and social behaviour, must be taken into account when assessing sustainability of bushmeat hunting in areas with spatially and temporally variable hunting pressure.

The communal forests in my study all exhibited several signs of human disturbances besides hunting, including tree felling for firewood, and construction poles, agriculture and human settlement. However, the destruction of indigenous forests for any purpose including agriculture and human settlement is unlawful according to the National Forests Act (Kepe, 2008). Other disturbances were ringbarking for medicinal purposes, livestock grazing, and

human traffic. Such disturbances may also have an impact on the mammal species densities and subsequent decreased hunter harvest rates in the communal forests of the region. Numerous other studies have also shown that forest mammals are sensitive to anthropogenic disturbances, displaying behavioural changes and human avoidance strategies with increased human presence (Zungu, 2018; Smith et al., 2019; Zungu et al., 2020; Ramahlo et al., 2022; Sosibo et al., 2024). The occupancy of forest mammals essentially depends on forest cover, leaf litter, and woody cover (Zungu et al., 2020). In forests with increased human activities in KwaZulu-Natal, Ehlers-Smith et al. (2018) found decreased occupancy of most forest dependent mammal species, confirming what was reported by the hunters in my study. To further emphasise the impact of human-induced landscape changes, Sosibo et al. (2022) found that in the Mistbelt forests of the Eastern Cape and KwaZulu-Natal land-use surrounding indigenous forests negatively influenced the occupancy rates of forest-dependent and generalist mammalian species.

Rural communities around South Africa have harvested wildlife species for millennia and this is still an ongoing practice. As highlighted by Martins and Shackleton (2019), bushmeat hunting in South Africa is widespread yet limited research efforts have been invested on the topic. This study shows that the extensive hunting may have significant negative effects on the population status of commonly targeted species and consequently requires urgent and in-depth research. The results of my study show that serious interventions are needed to address bushmeat hunting in communal tenure areas in South Africa as many mammal species are declining. With the various economic, political, health and environmental shocks experienced in the country in the past decades a large proportion of the population has been left with limited livelihood opportunities. As shown in numerous counties in Africa and globally, during times of national hardships and financial instability there is an increased reliance on wild species to meet livelihood needs (e.g. Rodríguez, 2000; Wittemyer, 2011; Gandiwa et al., 2013; Lindsey et al., 2021; Sulaiman et al., 2022).

Addressing the issue of unsustainable bushmeat hunting requires social-ecological reasoning as the bushmeat hunting system is a complex, adaptive system and sustainability hinges on the feedbacks and balances between social and ecological systems (Van Vliet and Nasi, 2015; Van Vliet et al., 2016; Froese, 2023). In incorporating complexity in assessing the sustainability of the bushmeat hunting system researchers consider the multi-functionality and socio-cultural significance of the hunting practice (Van Vliet and Nasi, 2015; Van Vliet et al., 2016; Van

Velden et al., 2020). Also acknowledging that sustainability is not one dimensional, depending on hunter offtake alone, but is multi-dimensional and is foremost dependent on spatial and temporal distribution of hunting effort (Nuno et al., 2014; Van Vliet and Nasi, 2015; Van Vliet et al., 2016; Van Velden et al., 2020). My analysis of social and ecological data provided evidence of the complex nature of hunting systems, showing the need for integrative approaches to understanding them.

This study indicates unsustainable offtake of most mammal wildlife species in the communal forests of the Eastern Cape. The unsustainable harvesting of mammal fauna in these forests represents a serious threat to biodiversity and to local communities. The local extinction of medium-sized mammal species will affect ecological processes, and the indigenous people will not be able to meet their cultural, sporting and livelihood needs. The hunters mentioned that the drivers of unsustainable hunting in the region are increased hunters due to unemployment and lack of community natural resource management. There exists an urgent need for decision-makers to consider integrating social-ecological systems thining into wildlife conservation policies. Furthermore, consultation with rural authorities and resource users is imperative to ensure community-based wildlife management towards sustainable use of wildlife species.

Detailed knowledge of species densities and of hunting practices are crucial to understanding a hunting system in space and time (Van Vliet et al., 2015). Given the recognized failure of simple biological models to assess the sustainability of bushmeat hunting, the combined use of social and ecological approaches provides an innovative path toward new approaches for the assessment of hunting sustainability (Deith, 2022). Combining the two is useful in understanding the evolution of both social and ecological systems compatible with the notion of sustainability (Van Vliet et al., 2010). Interdisciplinary assessments can also be used to encourage collective action and learning among different stakeholders (e.g., resource users, managers, scientific community) in community hunting management (Fromentin et al., 2022).

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Chapter 6
Synthesis, conclusions and recommendations

6.1 Introduction

Instrumental values view nature primarily for its utility, such as provisioning resources like bushmeat and other Non-Timber Forest Products (NTFPs) for subsistence or income (Cawthorn and Hoffman, 2015; Shackleton et al., 2011). Intrinsic values, on the other hand, recognize the inherent worth of wildlife and ecosystems, independent of human use (Batavia and Nelson, 2017). Relational values focus on the connections between people and nature, emphasizing cultural practices, identity, and sense of place, which are often reflected in the harvesting of NTFPs and bushmeat hunting traditions (Himes-Cornell et al., 2018; Sunderland et al., 2014). Both bushmeat and NTFPs sit at an intersection of these values, providing not only critical food and livelihood resources but also supporting cultural heritage and local customs (Nasi et al., 2011; Shackleton et al., 2011). Understanding where bushmeat and NTFPs align on this continuum can inform strategies that balance cultural practices with conservation and sustainability goals.

Globally, more than 3.5 billion people use or sell non-timber forest products (NTFPs), with the bulk of use and commerce happening amongst rural communities although there is still extensive urban use (Shackleton and de Vos, 2022). NTFPs play a crucial role in meeting people's daily livelihood needs by providing energy, foods, health, building materials, and more (Shackleton and Shackleton, 2003; Hadish, 2018; Mugido and Shackleton, 2019; Derebe and Alemu, 2023). Despite their significance and frequent use, there is a lack of comprehensive knowledge regarding the ecological and socio-cultural value of many NTFPs, including bushmeat, which impedes effective monitoring, regulation, and management (de Mello et al., 2020). The harvesting of mammal species is important in both developed and developing countries for their nutritional value, medicinal uses and cultural significance to humans (Nielsen et al., 2017; Lee et al., 2020). Bushmeat is a significant source of protein for many rural people in the tropics (Van Vliet et al., 2017; Friant et al., 2020), where the harvesting of NTFPs is sometimes the only source of household income and nutrition (Nasi and Fa, 2015; Torres et al., 2021).

While there is a wealth of literature on the use of bushmeat as a primary source of protein and income in tropical forests, research in the subtropical forests of southern Africa has been limited (Van Velden et al., 2018; Martins and Shackleton, 2019). Martins and Shackleton (2019) highlighted the prevalence of bushmeat use in the region, yet it remains under-researched. Recently, however, more attention has been given to the harvesting of bushmeat in the Southern African Development Community, shedding light on its importance to local communities (e.g. Young et al., 2018; Martins and Shackleton, 2019; Nieman et al., 2019; Kendon et al., 2022; Sosibo et al., 2022).

In South Africa there has been limited investigation into the dynamics of bushmeat harvesting in communal or state landscapes by rural communities. The handful of studies conducted in the region has not provided a comprehensive understanding of the contribution of bushmeat at a community and household level. Additionally, there has been no assessment of the impact of bushmeat hunting on faunal populations and whether or not the harvesting of bushmeat is sustainable. Consequently, the aim of this study was to investigate the nature, drivers, and implications of bushmeat hunting in rural villages neighbouring indigenous forests in the Eastern Cape province of South Africa, at both the community and household level. To answer the complex social and ecological research questions presented in the study, I used a mixed-methods approach to gather qualitative and quantitative data. As the thesis is organized in a paper format, the results of each empirical chapter have been discussed previously in the respective discussion sections of Chapters 2, 3, 4, and 5. In this chapter, I consider a summary of the key findings in relation to each of the research questions, reflect on limitations of the research and draw conclusions regarding the state of bushmeat hunting and use by rural communities living adjacent to the indigenous forests in the Eastern Cape. Finally, I make recommendations for policy and future research.

6.2 Research findings

6.2.1 Livelihood benefits associated with bushmeat hunting and use

Chapter 2 contributes to the existing knowledge of non-timber forest product (NTFP) harvesting and use by rural households in South Africa. The chapter presents novel and comprehensive findings on the use of bushmeat by rural households in the Eastern Cape. In recent decades, a plethora of studies have emphasized the significance of NTFPs to the

livelihoods of indigenous households in South Africa (e.g. Cocks and Wiersum, 2003; Dovie, 2003; Twine et al., 2003; Shackleton and Shakleton, 2004; Paumgarten, 2007; Maroyi, 2018; Mugido and Shackleton, 2019; Wale et al., 2022; Mugari et al., 2024). Extensive research has been invested in investigating the extent of NTFP harvesting (e.g. Leaver and Cherry, 2020; Sardeshpande and Shackleton, 2020; Martins and Shackleton, 2022), consumption (e.g. Paumgarten and Shackleton, 2011; Sardeshpande and Shackleton, 2019), and trade (e.g. Caspa et al., 2020; Wale et al., 2022) by rural communities living around forests in the region. Additionally, the safety and security net functions of NTFPs have also been a focal point of research, with various studies highlighting their importance in times of adversity (e.g. Shackleton and Shackleton, 2003; Mugido and Shackleton, 2017; Paumgarten et al., 2019).

My study echoed that rural communities harvest an array of NTFPs at different frequencies which are used to meet different household livelihood needs. The 486 rural households surveyed in the study harvested 11 types of NTFPs, with all of the households collecting fuelwood from the forests neighbouring their respective villages. More than three-quarters harvested medicinal plants, poles, wood (for utensils), and wild vegetables. Wild fruits, reeds, grass (for thatching), fish, and bushmeat were harvested by more than half of the households. These findings echo the widely accepted reality that NTFPs are widely used by rural households in South Africa (Shackleton and Shackleton, 2004; Njwaxu and Shackleton, 2019, Sardeshpande and Shackleton, 2020; Dalu et al., 2021). Sixteen percent of the households surveyed attested to having an active hunter within their homes. These were mostly unemployed young to middle-aged men who had no livestock. This validates the outcomes of the limited studies that investigated household bushmeat hunting in southern Africa, which show that hunting in the region is mostly done by unemployed young men (e.g. Gandiwa, 2011; Rogan et al., 2018; Van Velden et al., 2020; Sosibo et al., 2022). The findings of Chapter 2, and other studies from the sub-region, thus largely oppose the outcomes of multiple studies conducted in the moist, tropical regions globally, where all households have active hunters who were mostly elderly men, with families who sometimes own livestock (e.g. Kümpel et al., 2010; Friant et al., 2015; Morsello et al., 2015; Van Gils et al., 2019; Souza et al., 2022; Lemos et al., 2024).

In the global tropics bushmeat is mostly an unmanaged, common pool resource and for most rural communities it is the only available source of protein with little or no alternatives (Fa et

al., 2003; Van Vliet and Mbazza, 2011; Brittain et al., 2022). It is hence deemed as the mainstay of rural, and sometimes urban household, diets (Keylock, 2002; Schulte-Herbruggen, 2012; Booker and Wilson-Holt, 2020). In contrast, my results show that bushmeat was mostly consumed by adult males and boys within the households; and was rarely consumed by the entire family. Hunters consumed the meat amongst themselves and shared it with non-hunting males and young boys within the household or village. Most females did not consume bushmeat even if there was an active hunter within the household. Indeed, there are active taboos in the region against pregnant woman consuming bushmeat (Chakona and Shackleton, 2019). This confirms the findings of Manqele et al. (2018) who concluded that wild meat was not important to the livelihoods of rural communities in KwaZulu-Natal.

In light of these findings, I conclude that NTFPs are an important livelihood strategy for these communities, as most of the households in the study area made use of at least one NTFP daily. Also, the majority of the households had permanent structures (e.g. kraals for livestock) made from NTFPs which further demonstrate their reliance on forest products. The findings further show that while the economic and household contribution of bushmeat is limited, hunting remains culturally significant, embedded in local traditions and knowledge systems. Rather than serving as a primary source of household subsistence or trade, bushmeat is predominantly consumed by hunters and their male counterparts, reinforcing social cohesion and traditional practices. Hunting is often a communal activity, with many hunters attesting to hunting in groups with dogs and engaging in competition, highlighting the role of hunting in cultural traditions and as a social activity. The region holds a wealth of local ecological knowledge related to hunting, which is passed down through generations.

6.2.2 Hunting practices by rural communities in the Eastern Cape

The aim of Chapter 3 was to provide a detailed account of hunting practices by rural hunters living in the villages neighbouring forests in the Eastern Cape. I specifically focused on (1) how distance to forests influenced hunting practices, (2) what motivated hunters to hunt, (3) the methods they used to capture prey and (4) how hunters perceived hunting, the animals they caught and the forest ecosystem as a whole. An abundance of studies have assessed bushmeat hunting systems in different settings globally (e.g. Fa et al., 2002; Wilcox and Nambu, 2007;

Wright and Priston, 2010; Swamy and Pinedo-Vasquez, 2014; Van Gils et al., 2019; Van Velden et al., 2020) with most hailing from the global tropics.

The spatial distribution of hunting pressure has been well-documented, with studies showing that hunters at close proximity to hunting grounds hunt more frequently than those from further away (Ziegler et al., 2016; Deith and Brodie, 2020; Duporge et al., 2020). The results of this chapter largely confirm these findings as I found that throughout the study area hunters from the villages close to the forests hunted more frequently and caught more animals than hunters from the villages further away. Also, the close villages had significantly more hunters than the far villages.

In the tropical regions bushmeat hunting is reported to stem from community or household-level poverty (Swamy and Pinedo-Vasquez, 2014; Nielsen et al., 2018; Torres et al., 2021), hence, in these regions bushmeat is used for household consumption or traded for financial gain to meet the household livelihood needs (Fa et al., 2009; Fargeot et al., 2017; Torres et al., 2023). Numerous other motivations behind bushmeat hunting have been documented in the literature, including culture (Friant et al., 2015; Morsello et al., 2015; Chausson et al., 2019), sport and recreation (Souto et al., 2019; Van Velden, 2020; Afriyie et al., 2021) and medicinal purposes (Van Vliet et al., 2017; Lee et al., 2020). My findings from interviews conducted with hunters revealed that hunting was primarily motivated by culture and sport/competition. Two-fifths of the hunters in the study mentioned that they hunted because it was part of their culture and that they enjoyed hunting. This was closely followed by sport or competition, mentioned by one-third of the hunters. Other motivations included recreation and income. Contrary to most studies which assessed the motivations of hunting in the tropics and other landscapes, subsistence and income were not amongst the motivations for hunting in the subtropical forests of the Eastern Cape. At most, hunters shared their catch amongst themselves, with other non-hunting males and young boys from their villages.

Hunters use different methods to capture prey, as revealed by several studies have documenting the hunting practices of rural hunters (Wright and Prinston, 2010; Lindsey et al., 2015; Golden, 2009; Rist et al., 2010; Pangau-Adam et al., 2012; Van Gils et al., 2019; Van Velden et al., 2020). These studies show that sport and recreational hunters use dogs or ride horses to corner wildlife and use locally made guns, sticks or machetes to dispatch the animal. Subsistence

hunters may also set traps or wire snares to increase the chances of catching prey (e.g. Carpaneto and Fusari, 2000; Dobson et al., 2019; Nieman et al., 2019; Young et al., 2019). As most of the hunters in the study were motivated by culture and sport, the use of dogs during hunting trips was the primary hunting method in the study area. Hunters used sniffer dogs to locate prey species, greyhounds and other dog breeds were used to chase down and corner the prey and the hunters would then kill the animal with sticks or machetes. It was common for hunters to set wire snares at different points during or before the hunt to increase the chances of catching prey by the end of a hunting trip. All the hunters with dogs cherished their dogs. None of the hunters hunted daily and only a handful of hunters attesting to hunting weekly. Most hunters hunted every other month, or at least once a month. Hunting trips would mostly be social events on weekends, at which approximately 10 hunters with a pack of 30 dogs or more competed with each other on who caught the most animals and who had the fastest dogs. Large hunting events were also common, where hunters from different villages loaded their dogs into minibus taxis to compete in hunts in a predetermined location. The subsistence hunters and those who mentioned that they sold part or all of their catch also took part in these events but mostly hunted alone using wire snares, checking these frequently during the week.

The current illegal status of hunting outside formal hunting reserves or private property did not deter hunting in the region. The hunters acknowledged that they were aware of the illegal nature of the practise, yet they still hunted. Hunters continue to harvest wildlife in the communal forests in the region, and more than half also hunted within protected areas neighbouring their respective villages. Though they risked being arrested, the hunters mentioned that they were guaranteed to catch prey when hunting in the protected areas. The hunters also mentioned that wildlife escapes from the communal forests to find refuge in the protected areas and hence the hunters feel some of the wildlife in the protected forests belonged to them. Though most of the hunters did not particularly want their children to be hunters, some dint want their children to hunt as it was part of their culture. All the hunters valued the forests as a place that provided important natural resources for the community and also for its cultural, heritage and spiritual values.

6.2.3 Mammal species diversity under hunting pressure in the forests of the Eastern Cape

In Chapter 4, I used a mixed-methods approach to investigate the diversity and abundance of mammal species under hunting pressure in the forests of the Eastern Cape. Using ecological sampling in the form of line transect surveys, I assessed mammal species richness and abundance indices in six communal forests in the province. I then compared the results from the communal forests to the species richness and abundance estimates from adjacent protected forests. I further employed local ecological knowledge (LEK) surveys with regular forest users and hunters from the villages around the forests. I also interviewed local experts from the protected areas in the region. Integrating both ecological and social methods enhanced the precision of the results enabling a more comprehensive study of the impact of bushmeat hunting on mammal fauna in the area.

The hunting of wild animals for consumption and trade has been shown to have detrimental consequences on the harvested prey species in many locations (Ripple et al., 2016; Benitez-Lopez et al., 2017; Braga-Pereira et al., 2021; Hughes et al., 2023). This is the case for many large mammal species in the tropical forests of Africa, Asia and South America (Fa and Brown, 2009; Ripple et al., 2016; Evan et al., 2020; Fa et al., 2022). The harvesting of wild fauna is intimately linked to several human development challenges' including food insecurity, land-use changes, and emergent disease risks (Ripple et al., 2016; Lee et al., 2020; Booth et al., 2021). Hunters tend to prefer large mammal species as these have more meat and secondary products like horns and skins which can be traded (Djagoun et al., 2018). Due to their low intrinsic growth rates, large species are more susceptible to local extinction when overhunted (Ripple et al., 2016). The wildlife species in unmanaged communal forests are often a free for all, common pool resource, which may result in the unsustainable harvesting of many mammal species (Ripple et al., 2016). With the declining wildlife populations outside protected areas, poaching pressure is increasing in many nature reserves and parks globally (Rija et al., 2020).

The ecological surveys detected more mammal species and more animals per species in the forests within the protected areas than in the communal forests in both Afromontane and Coastal regions. The Afromontane and Coastal communal forests had similar species richness and diversity, with the large-spotted genet and water mongoose undetected in both forest types. In the Afromontane region, samango monkeys were the most common species. Bushbuck and common duiker were detected in all the Coastal communal forests. The forests within the

protected areas had higher species abundance than the communal forests. Also, all the forest mammal species detected in an earlier survey by Hayward et al. (2005) were detected in the protected forests.

The LEK surveys with regular forest users and hunters revealed greater species richness and abundance in the communal forests than what was detected by the line transects conducted in the same forests. The indigenous people of the Eastern Cape who used the forests regularly had significant knowledge of the mammal fauna within the forests. The hunters provided more insights on the mammal species present in their respective forests than did the regular forest users. Also, the hunters and regular forest users from the villages close to the respective forests had more LEK on the species richness than their counterparts from more distant villages. The same was observed with hunting pressure, as the hunters from nearer villages harvested more prey than the hunters from further villages.

The significant difference in mammal species diversity between the protected and communal forests is likely to be consequence of the higher anthropogenic pressure, including hunting in the communal forests. A considerable number of human disturbances to the communal forests were recorded during the line transects, including tree felling (for settlement, agriculture, and firewood), livestock grazing, logging, bark stripping, and snaring. Anthropogenic disturbances were recorded in all transects conducted in the Afromontane and Coastal communal forests. The results from the line transects confirm the findings of numerous studies conducted in the subtropical forests in South Africa that highlight the negative impacts of anthropogenic disturbances to forest ecosystems and the mammal species communities within (e.g. Ehlers-Smith et al., 2017; Zungu, 2018; Smith et al., 2019; Oberosler et al., 2020; Zungu et al., 2020; Sosibo et al., 2022).

The combination of ecological and LEK surveys yielded a more reliable estimate of forest mammals species richness in the forests. LEK-based methods have largely been neglected by wildlife researchers; my study demonstrates the effectiveness of the method in estimating vertebrate diversity in forest environments. As shown by Braga-Pereira et al. (2022) LEK surveys can be used concurrently with line transect surveys to gain better diversity estimates and document species that are rarely sighted during direct surveys, but frequently observed by local people. Therefore, the integration of indigenous and scientific knowledge could expand knowledge of forest fauna and nurture the development of effective policies to support biodiversity conservation goals.

6.2.4 Sustainability of bushmeat hunting in the indigenous forests of the Eastern Cape

Chapter 5 provides a novel assessment of the sustainability of bushmeat hunting in the subtropical forests of South Africa. The study is the first to assess the sustainability of bushmeat hunting in the country. In this chapter I continue using integrative, social and ecological methods to gain insights on the how bushmeat hunting affects mammal species densities in the communal forests of the Eastern Cape. Also, how changes in wildlife populations affect hunting practices and hunter behaviour. As hunting systems are complex and adaptive analysis requires social-ecological systems thinking, as single method approaches may yield inaccurate outcomes, potentially resulting in incorrect policy recommendations. Several studies have illustrated the complex nature of bushmeat hunting also show that assessing the sustainability of bushmeat hunting should not only be determined by analysing the impact on the species population only, but should also consider the hunters' socioeconomics and changes in practices and behaviour (Nuno et al., 2014; Van Vliet et al., 2015; Van Velden et al., 2020; Trefon, 2023; Froese et al., 2023; Lemos et al., 2024).

The density estimates of the five most hunted species from the communal forests were significantly less than those acquired from the protected forests and those reported in the South African literature. Also, based on the sustainable offtake parameters for medium-sized mammal species given in Robinson (2000) and in Robinson and Bennett (2004), I determined that bushmeat harvesting in the communal forests of the Eastern Cape is currently unstainable. These findings were also supported by the participatory surveys conducted with the hunters in the region, with the vast majority mentioning that their harvest rates had decreased in the past 10 years. This has subsequently led to a decreased catch per unit effort as hunters spend more time hunting and caught fewer animals. This has also triggered changes in their hunting practices and behaviours as some hunters have now decreased their hunting frequencies, whilst others risk prosecution and hunt in the adjacent protected forests. The hunters also mentioned that other anthropogenic activities including forest destruction, NTFP harvesting and increased human traffic have also caused some mammal species to move into the protected forests and some have changed their behaviour and ecology.

The triangulation of results sourced from the social and ecological datasets suggest currently unsustainable bushmeat offtake in the communal forests of the Eastern Cape. The unsustainable nature of hunting in these forests has caused declines in the mammal species populations. The

overexploitation has further caused undesirable impacts on the social and cultural well-being of the hunters as harvest rates have decreased and hunters are unable to fully meet their sociocultural needs. The results of this chapter highlight the need to consider the hunting system as a complex social-ecological system where sustainability is determined through assessing both ecological and social dynamics.

6.3 Deciphering the complexity of hunting systems

Bushmeat hunting is a complex issue that is intimately linked to development and is influenced by a diverse range of factors that vary according to locations and contexts (Van Vliet and Mbazza, 2011; Ripple et al., 2016; Deith, 2022). The hunting system cannot be considered in isolation, as it is characterised by various interconnected factors including governance, economic, social, cultural, and ecological factors (Pretty, 2011; Biggs et al., 2021). This complex system exhibits non-linear dynamics, feedback loops and emergent behaviours, making it challenging to understand and manage. In the Eastern Cape bushmeat hunting is intimately linked to the culture of the indigenous Xhosa people and is mostly a social activity, practiced by young and middle-aged men. Also, my results show that in the region hunting is mostly done using mixed hunting methods. Unlike in the tropical regions where hunting is mostly for subsistence and trade (Van Vliet et al., 2017), and traps are the primary hunting method (Wilcox and Nambu, 2007; Wright and Priston, 2010). My results further show that hunting is unmanaged in the communal forests in the region, leading to a decrease in mammal species diversity and densities which in turn negatively impacts hunting success. This has hence altered hunting behaviour and practices as hunting in protected areas has increased and some hunters have changed hunting frequencies. Also, in this region, bushmeat trading is a discreet practice, primarily catering to elderly men who have a cultural preference for bushmeat from past hunting experiences. Unlike tropical regions, where bushmeat plays a significant role in local economies and food security, the trade here is less economically central and more culturally driven. This contrast highlights the complexity of bushmeat hunting, which exhibits nonlinear dynamics influenced by ecological, economic, and cultural factors that vary between regions (Fa et al., 2022; Ripple et al., 2021; Cawthorn & Hoffman, 2023; Wilkie et al., 2021).

Addressing the complexity of bushmeat hunting requires interdisciplinary approaches considering the interplay between social and ecological factors (Parrott et al., 2012). It is increasingly acknowledged that addressing bushmeat hunting requires an integrated approach

that accounts for the multiple interlinkages and dependencies between social and ecological systems (Biggs et al., 2015). Hence, when assessing bushmeat hunting and use in the Eastern Cape the current study employed mixed social and ecological methods to decode the complex nature of the hunting system in the region. The study was framed around the social-ecological systems framework (SESF); through this framework, the study generated holistic insights on bushmeat practices by rural communities. Addressing the hunting system requires new and expanded frameworks and approaches for understanding the world in which we live and informing policy and practice (Ingram et al., 2021). Adopting a systems-thinking perspective when analysing hunting systems, improves the possibilities of developing effective solutions that balance human livelihoods, conservation, and sustainable development. Consequently, the results from this study are expected to inform decision-makers and make recommendations regarding bushmeat hunting and use to advise both conservation and developmental policies.

Hunting systems are self-organizing, and continuously evolving in reaction to external shocks and internal changes to the system (Levin et al. 2013). Hunters adapt to changes in the population and behaviour of prey species, whilst prey species may alter their behaviour due to hunting pressure. Hence understanding the interactions and dynamics within a hunting system is at least partly a moving target, and managing these systems requires continual learning and adaptation of management strategies (Biggs et al., 2015; 2021). Uncertainty may also result from interactions between the components of the system (i.e. the hunters, prey species, or law enforcement) that give rise to emergent properties such as feedback loops and thresholds, especially non-linear behaviour (i.e. population collapse or recovery) that cannot be predicted from knowledge of the individual system parts (Marrocoli et al., 2018; Van Velden et al., 2020). In the hunting system, societal values such as respecting community hunting restrictions also play a critical role in determining the desired social and ecological outcomes, resolving trade-offs, and influencing the hunters tolerance for risk and uncertainty (Van Vliet et al., 2015; Van Velden et al., 2020). Differences in socio-cultural values such as beliefs, among different hunting communities and changes in these values over time may create substantial uncertainties about managing hunting systems (Dobson et al., 2019).

As hunting systems have several uncertainties these give rise to complexity within the system (Marrocoli et al., 2018; Van Velden et al., 2020). Analytical complexity is the difficulty of understanding complex systems, both because the system itself is complex and because knowledge of the overall behaviour of the system is always partial (Biggs et al., 2015; Van

Velden et al., 2018; Biggs et al., 2021). Ontological complexity is a result of erratic (non-linear) behaviour of hunting systems (Biggs et al., 2015). Societal complexity comes from the different socio-cultural meanings, benefits, and purposes that different hunting communities attach to bushmeat hunting (Van Velden et al., 2018; Biggs et al., 2021). It is crucial to recognize the cultural significance of bushmeat in many hunting communities (Wilkie et al., 2016; Van Velden et al., 2020), where it is a vital source of protein and an integral part of traditional practices ((Wilkie et al., 2016). Any attempts to regulate or manage bushmeat hunting must be sensitive to these cultural nuances (Van Velden et al., 2018; Van Velden et al., 2020). Recognizing these different aspects of complexity is essential to developing strategies to manage complex hunting systems. Inherent complexity in hunting systems is a key contributor to the ongoing bushmeat crisis in the African tropical regions (Van Velden et al., 2018; Van Velden et al., 2020).

Over the past decades, various approaches have been proposed to address the complexities and uncertainties of bushmeat hunting systems (e.g., Nuno et al., 2014; Van Vliet et al., 2015; Marrocoli et al., 2018; Van Velden et al., 2020). To navigate these challenges in the Eastern Cape, I propose adaptive management and co-management strategies (Biggs et al., 2015). Adaptive management offers a flexible, learning-based approach to respond to complex and dynamic interactions within hunting systems (Van Vliet et al., 2015). Co-management emphasizes collaboration among local leaders, hunters, conservationists, and government officials, promoting shared governance and accountability (Lubilo and Hebinck, 2019). However, implementing these models in communal forests not under direct government control presents challenges, including elite capture, varying decision-making capacities, and aligning traditional and formal governance systems. Successful examples from Africa, such as Namibia's community-based wildlife management (Lubilo and Hebinck, 2019), joint conservation in the Congo Basin (Nasi and Van Vliet, 2012), and collaborative reserve management in Ghana (Osumanu and Atia, 2017), demonstrate that adaptive co-management can enhance both conservation and livelihoods when effectively designed and supported over the long term. These initiatives highlight the potential for creating resilient socio-ecological systems that balance sustainable resource use with community well-being.

Secondly, engaging and integrating different perspectives in complex hunting systems is a crucial step towards sustainable and equitable management of wildlife species (Biggs et al., 2015; Biggs et al., 2021). This involves bringing together diverse stakeholders, to share knowledge, values, and beliefs (Van Velden et al., 2020). By fostering a collaborative

environment, participants can collectively identify goals, priorities, and solutions that balance human needs and ecological integrity (Coad et al., 2018). Integration of traditional ecological knowledge, scientific research, and local experiences enhances the understanding of complex social-ecological dynamics, leading to more informed decision-making (Stone and Stone, 2022). Active engagement and integration also facilitate the development of innovative management strategies, adaptive governance, and effective conflict resolution mechanisms (Van Velden et al., 2020). Moreover, they promote mutual learning, trust, and cooperation among stakeholders, promoting the long-term sustainability of hunting practices, ecosystem services, and human well-being (Nuno et al., 2014; Gray et al., 2015). By embracing diverse perspectives and knowledge systems, complex hunting systems can navigate the complexities of social-ecological systems, achieving a balance between human livelihoods and ecosystem health (Groom et al., 2023).

The third strategy is to facilitate self-organization. Self-organization is a fundamental property of complex hunting systems, whereby adaptive interactions among hunters, wildlife, and their environment give rise to emergent patterns and processes that sustain system structure and function (Biggs et al., 2015; Van Velden et al., 2018; Van Velden et al., 2020). Through a process of dynamic feedback and adaptation, hunters develop strategic responses to changing wildlife populations, habitat dynamics, and social norms, leading to the emergence of more resilient hunting practices (Van Velden et al., 2018; Van Velden et al., 2020). This self-organization is facilitated by the autonomy and decision-making capacity of hunters, enabled by their local knowledge, social networks, and cultural traditions (Bachmann et al., 2020). As a result, complex hunting systems exhibit adaptive capacities, such as the ability to adjust harvest rates or sites, protect critical habitats, and maintain social cohesion, all of which contribute to the long-term sustainability of the system (Brinkman et al., 2007). By recognizing and supporting self-organization in complex hunting systems, managers and conservationists can promote adaptive and sustainable practices that align human needs with ecological integrity (Abebe et al., 2020). Practical strategies to achieve this include fostering social cohesion and building community capacity to engage with biological sustainability concepts. Lessons from the Sustainable Wildlife Management (SWM) Programme demonstrate effective approaches such as establishing wildlife clubs, implementing hunter-led monitoring, and strengthening community governance structures. These initiatives enhance legitimacy, capacity, and technical knowledge within communities, enabling them to develop and enforce sustainable hunting practices while maintaining local ownership and accountability.

Lastly, to deal with complexity within hunting systems in the Eastern Cape I suggest setting boundaries to avoid system thresholds (Biggs et al., 2015). Hunting in the region is currently illegal, hence boundaries are ignored. Legalising licensed subsistence hunting and restricting hunting in certain faunal depleted areas will ensure hunters accept and respect boundaries. In complex hunting systems, setting boundaries is a crucial management strategy to avoid crossing critical thresholds that could lead to regime shifts and irreversible ecosystem degradation (Biggs et al., 2015; Fougères et al., 2020). In rural areas, setting boundaries could involve implementing buffer zones or spatial prioritization approaches, with customary authorities playing a crucial role in enforcing environmental laws and promoting sustainable resource use in communal forests where formal legal frameworks may be lacking. By establishing limits on harvest rates, hunting practices, and spatial and temporal access, traditional leaders, hunters and other decision-makers can limit or prevent the depletion of key species, maintain ecosystem resilience, and preserve biodiversity (Pattiselanno et al., 2024). Boundaries must be informed by scientific research and monitoring and be adaptive and flexible to account for uncertainty and changing conditions (Taylor et al., 2015; Groom et al., 2023). Co-management with stakeholders, including indigenous communities and hunters, is essential for ensuring the effectiveness and legitimacy of boundaries (Groom et al., 2023). By setting and enforcing boundaries, complex hunting systems can avoid tipping points, maintain ecosystem services, and support sustainable hunting practices, ultimately ensuring the long-term sustainability of both human livelihoods and ecosystem health (Biggs et al., 2015).

The urgent sustainability challenges facing forest mammal fauna in the communal forests of the Eastern Cape demand new and expanded frameworks and approaches for understanding and managing interconnected and interdependent social, economic, and ecological systems (Biggs et al., 2015). The growing literature on hunting systems as complex adaptive systems emphasizes that policies for managing hunting systems in the face of substantive uncertainty will be central to our ability to engage with the bushmeat sustainability challenges faced in the communal forests in the region. I suggest four strategies to address complexity in bushmeat hunting systems in the region. Biggs et al. (2015) shows that it is possible to effectively implement these strategies in pragmatic ways that can make a real difference on the ground and foster more sustainable trajectories of change.

6.4 Limitations of the study

The study largely accomplished its goal of unravelling bushmeat practices by rural communities living adjacent to indigenous forests in the Eastern Cape province of South Africa. The study contributes novel insights to the harvesting and sustainability of mammal fauna in the subtropical forests of South Africa. However, the study findings do not fully reveal certain potential limitations that were encountered during the study. This section provides a self-critique by outlining some of the limitations of the study.

The first limitation was being unable to follow hunters during hunting trips to collect first-hand data on hunting practices and methods employed by hunters in the study area. Conducting hunter follows is a valuable method to obtaining accurate and detailed data on bushmeat hunting activities (Kümpel et al., 2009). This approach involves accompanying hunters into the field to observe their hunting practices, behaviours and interactions (Nielsen, 2006; Kümpel et al., 2009). By directly observing hunters in action I could have gathered real-time data on the species targeted, hunting techniques used, hunting success rates, distances travelled and other important information that may not be accurately captured through the surveys and interviews conducted (Lindsey et al., 2015). Because hunting is illegal in region, the Eastern Cape Department of Economic Development, Environmental Affairs and Tourism would not provide permits to me to conduct hunter follows. Whilst understandable, this compromised the study and limited some data that would have been hugely useful to the conservation of the species that this department is entrusted to conserve.

My study provided valuable insights into the prevalence, patterns and drivers of bushmeat hunting and use by rural inhabitants residing adjacent to forests in the Eastern Cape. Nonetheless, there are serval limitations associated with conducting short-term studies on such a sensitive topic. The study only captured a snapshot of bushmeat practices over a one year period based on respondent recall. This limited temporal scope hindered my ability to assess long-term trends and seasonal variations (Bogina et al., 2023). Also, respondents could have provided inaccurate or incomplete information due to social desirability, memory recall issues or fear of repercussions (Reisinger, 2022). To address these limitations, there is a need for long-term studies that survey a larger sample of communities surrounding bushmeat resource areas with long-term monitoring efforts, qualitative research methods, participatory approaches, and interdisciplinary collaborations. To further minimize social disirabilty bias I suggest the use of techniques such as randomized response techniques (RRT) or anonymous surveys to encourage

more honest reporting. These methods have been shown to reduce social desirability bias and improve the accuracy of data on sensitive topics, providing more reliable estimates of bushmeat hunting prevalence and motivations.

The study used line transects to survey the densities and diversity of hunted mammal species in the forests of the Eastern Cape. Using line transects to survey the densities of prey species can be a valuable tool for monitoring wildlife populations and assessing the impact of hunting activities (De Andrade Melo et al., 2015; Hušek et al., 2021). However, this method also has its limitations, one being the assumption of uniform detectability along the transects, which may not always hold true in reality (Buckland et al., 2010). Factors such as habitat characteristics, animal behaviour, and sampling conditions can all influence the detectability of prey species and lead to biased density estimates (Keeping and Pelletier, 2014). Camera trap surveys are a more effective method than line transects for surveying hunted mammal species in forests (Fragoso et al., 2016). Camera traps provide a non-invasive and unbiased approach, capturing images of animals without disrupting their behaviour (Hegerl et al., 2017). Camera traps also allow for continuous monitoring over extended periods, providing a more comprehensive understanding of species presence, abundance, and behaviour (Fragoso et al., 2016; Hegerl et al., 2017). While the use of camera traps in the study could have yielded a better understanding of mammal species densities and diversity, their use comes with significant expenses, particularly in areas with high human activity (Burton et al., 2015; Meek et al., 2019). The risk of camera trap theft or damage by humans is high in open access communal landscapes (Meek et al., 2019). In areas with high human activity, camera traps may need to be protected with additional security measures, such as enclosures or anti-theft devices, adding to the overall expense (Meek et al., 2019). As a result, the cost-effectiveness of camera traps as a survey method may be reduced in communal forests with high human activity, making alternative methods such line transects a more feasible option.

6.5 Conclusions

This study is the first comprehensive assessment of bushmeat hunting in the subtropical forests of South Africa. It provides a comprehensive appraisal of bushmeat hunting and use by rural communities residing adjacent to biodiversity rich landscapes. As a first of its kind the study can be used as a model for other studies assessing bushmeat hunting elsewhere in the country.

The thesis presents insights on household bushmeat consumption, showing that bushmeat is not essential to the livelihoods of rural communities in the region. I further provide in-depth findings on hunting practices of hunters and show that the spatial proximity of villages to natural resource rich areas plays a significant role in the frequency and quantity of extraction. Also, the key motivations behind hunting in the subtropical forests differ from what has been reported from the tropical regions, with culture being the prominent reason for hunting in the area. Hunting was determined to have detrimental effects on the diversity of forest mammal species as the abundance and richness of the species in communal forests was less that that of the protected forests. Also, LEK surveys conducted with key informants and resource users reported low abundance for most of the mammal species in the communal forests. The study also provides a novel approach to detaining the sustainability of bushmeat hunting through mixed social and ecological methods. Both the social and ecological methods suggested unsustainable offtake for three of the five most hunted mammal species in the communal forests of the Eastern Cape. To address the unsustainable bushmeat hunting in the subtropical forests, there is an urgent need for the integration of science into policy-making to achieve the desired conservation and livelihood objectives. Further, long term-research on this topic is necessary to gain additional support to the evidence provided in this thesis.

6.6 Recommendations for policy

Natural resources make a significant contribution to the livelihoods and subsistence of rural people in southern Africa (Robinson, 2016; Wale et al., 2022; Magidi, and Hlungwani, 2023). In the region, terrestrial ecosystems and the wild species within, support the livelihoods of many households, particularly in marginalized communities (Herd-Hoare and Shackleton, 2022; Maroyi, 2022; Mograbi et al., 2023). There is growing concern on the levels of wild species harvesting due to increasing human populations and amplified commercial use of wild species (Van Wyk and Prinsloo, 2018; Semenya and Maroyi, 2019; Van Velden et al., 2020; Taylor et al., 2021; Nenungwi et al., 2024). Various management tactics and strategy improvements have been tested to address the issues of depletion and degradation of natural commons (Hassen et al., 2019). Yet, some of these did not adequately accomplish the desired conservation intentions and, in many cases, exacerbated the conflict between local livelihoods and conservation goals (Ward et al., 2018).

The governance of harvesting common pool resources such as bushmeat remains perplexing in South Africa as in many parts of the world (Child, 2019; Hassen et al., 2019; McClanahan, 2024). The IPBES report on the sustainable use of wild species highlights the importance of effective governance for the sustainable harvesting of common pool resources (Fromentin et al., 2023). In the Eastern Cape forests most of the hunting is conducted with dogs and snares both which are illegal in terms of the Animals Protection Act no 71 of 1962, and the Nature Conservation Ordinance no 19 of 1974. Yet, uncontrolled hunting is commonplace in the communal forests with some of the hunted species listed as threatened (e.g. blue duiker). The use of snares and traps for hunting is strictly prohibited whilst some uncertainty exists regarding the use of dogs for hunting purposes, as in some areas wounded wildlife may be tracked and/or cornered using dogs (Anthony et al., 2010). Hunting with dogs has a long cultural history in the region, tethered to tradition and subsistence (Chambers, 2020). Despite the clear roots in cultural practices and traditions, dog hunting has become a sport and a gambling opportunity in many places in rural and peri-urban settings of the Eastern Cape and South Africa as a whole. Hunting with dogs for sport and gambling is progressively becoming more common compared to known cultural practices (Chambers, 2020).

The IPBES report emphasizes the importance of implementing effective policies on bushmeat hunting to balance the conservation of wild species with the needs and well-beingof local communities, ensuring the long-term sustainability of both (Fromentin et al., 2023).There is an urgent need to revise policies regarding hunting in the communal lands in South Africa, as the current policies are failing to achieve the desired conservation objectives and are inconsiderate of the livelihood and socio-cultural needs of rural communities. Excluding the general population in policy-making has contributed to the current unsustainable hunting trends seen in the communal landscapes nationally. Community-wide participation and consultation with the resource users in establishing new policies and frameworks around hunting are needed. Various studies highlight the importance of community engagement and participation in achieving both conservation and livelihood aims (e.g. Turner, 2004; Jones and Murphy, 2013; Dube, 2018; Ndoye et al., 2021; Dhliwayo et al., 2023). Furthermore, the establishment of community-based, natural resource management schemes with government incentives for communities who maintain certain levels of biodiversity could maybe assist in the protection of wildlife and also the social upliftment of rural communities in the region.

In light of the findings of the study I further recommend that in certain communal landscapes regulated sport and recreational hunting be permitted. By allowing controlled hunting practices, communities can benefit from the economic value of wildlife as bushmeat can be legally traded, incentivizing conservation efforts and reducing human-wildlife conflict (Stone and Stone, 2022). Regulated hunting can also help manage wildlife populations, maintaining healthy ecosystems and promoting biodiversity (Lee et al., 2020). Seasonal hunting restrictions can advocate that hunting occurs only during designated periods, minimizing the impact on vulnerable species and allowing for population recovery (Van Gils et al., 2019). Additionally, I propose the establishment of local offices or systems through community leaders, such as chiefs, to facilitate hunting licence applications in rural areas. Currently, many hunters face challenges accessing permits due to the centralization of permit offices in urban towns. By creating accessible points of contact in rural communities, this approach would ensure more equitable access to permits, promote regulated hunting practices, and support sustainable wildlife management in these regions. However, strict regulations and monitoring must be in place to prevent overhunting and ensure that hunting practices align with conservation goals, safeguarding the long-term sustainability of communal forests and their rich biodiversity (Deith, 2022). Several studies have shown that small and medium-sized mammal species are able to recover from heavy hunting when adequate hunting regulations are put into place and when communities are consulted in management decisions (e.g. Topp-Jørgensen et al., 2009; Benitez-Lopez et al., 2017; Dobbins et al., 2022). In the tropical forests Marrocoli et al. (2018) show that participatory monitoring systems are important in promoting the sustainable use of a common-pool resource such as bushmeat. In complex social-ecological systems, such as bushmeat hunting, hunter self-monitoring could be a useful tool to initiate behavioural changes as well as promoting sustainable use of wild meat.

Building bridges between environmental, social and political programmes is crucial in the face of escalating human pressures on wild species (Thomas et al., 2019). In light of the existing biodiversity conservation issues, the integration of science into policy-making is imperative in evolving science-based, environmentally sound and sustainable policies (Watson, 2005; Von der Heyden et al., 2016; Avgerinopoulou, 2019; Aguinis et al., 2022). In a global perspective, scientists, citizens and politicians are increasingly working together in cooperative networks to achieve sustainable, science-based policy-making. Prominent examples are the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

and the United Nations Intergovernmental Panel on Climate Change and the Sustainable Development Goals for 2030. These working groups continue to play a fundamental role in tackling global environmental challenges (Thomas et al., 2019; Fromentin et al., 2022). In South Africa, numerous provincial working groups have been formed to assist in the mitigation of different biodiversity challenges each province is faced with (Brownlie et al., 2017). Also, private protected areas and biodiversity stewardship initiatives have emerged in recent years as a cost-effective tool for achieving protected area and conservation area expansion (Cousins et al., 2008; Cockburn, 2018; Wright et al., 2018). Stewardship and private protected areas are aimed at improving the sustainability of local socio-ecological systems (Cockburn, 2018). Serval initiatives and projects are being conducted on communal landscapes promoting sustainable natural resource use and sustainable stewardship of nature. Organisations like the South African Biodiversity Institute Conservation South Africa and World Wide Fund for Nature (WWF) and other organisations have numerous ongoing community-based projects on communal area that benefit both species conservation and community development and livelihoods.

The current study emphasizes the importance of including socio-ecological systems frameworks in policies that involve the harvesting of wildlife. When making decisions pertaining to the conservation of wildlife it is essential to recognize that wildlife is part of a multi-faceted and complex SES (Ostrom, 2007). Without comprehensively exploring social and ecological factors, conservation policies can result in unsuccessful conservation and livelihood goals (Brehorny et al., 2020). For policies to effectively address issues within an SES, they require cautious assessment of the complex, non-linear and multi-variable interfaces, and how these are evolving through time (Decker et al., 2019; Brehorny et al., 2020). The use of SES frameworks allow policy-makers to move beyond simple panaceas, and progress towards a solution that considers the source, and possible amelioration, of poor outcomes for ecological and human systems (Ostrom and Cox, 2010). Also, SES frameworks unambiguously account for the influence of various social factors (i.e. institutions, individuals and governance structures) which most conservation planning processes inadequately address (Andries et al., 2022). This further highlights the need to incorporate SES frameworks in policies such as those governing bushmeat hunting in South Africa.

Ideally, more detailed, long-term research is required to make concrete policy recommendations. However, the feasibility of some of my policy suggestions will not be clear without field-testing, and therefore at some point research must translate into action. Finally, changing economics, politics and human behaviour mean that any management of bushmeat hunting must be adaptive, and the success of any policy monitored and evaluated on a regular basis (Van Velden et al., 2020)

6.7 Recommendations for future research

Bushmeat hunting and use is common throughout South Africa and is harvested in communal landscapes across the country (Martins and Shackleton, 2019). However, there is a dearth in knowledge on the extent, drivers and ecological impacts of bushmeat hunting in the country (Martins and Shackleton, 2019). Little effort has been invested in comprehensive studies which give detailed evidence of hunting practices and the resulting impact of wildlife species. The little investigation that has been conducted on bushmeat hunting and use in various landscapes across the country shows the importance of bushmeat hunting for subsistence, medicine, culture and sport (White, 2004; Hayward, 2009; Shackleton et al., 2007; Kaschula and Shackleton, 2012; Manqele et al., 2018; Van Velden et al., 2018; Young et al., 2018; Martins and Shackleton, 2019; Nieman et al., 2019; Sosibo et al., 2022). Yet, these studies have not provided a holistic understanding of bushmeat hunting at a community and household level.

As pointed out by most of the hunters in the region, no consultation with communities and resource users has ever been done to inform the current hunting regulations. Decision-making in complex, social-ecological systems is challenging, especially given that limited information on bushmeat hunting is available in the county. Without adequate scientific evidence, it is difficult to achieve conservation and livelihood outcomes ensuring that communities benefit from wildlife (Van Velden et al., 2018; Stone and Stone, 2022). I hence recommend research that will integrate participatory action research (PAR) (Blangy et al., 2024) and participatory modelling (PM) (Van Velden et al., 2020), engaging all the stakeholders involved in the bushmeat system to develop and define research problems, develop questions, collecting, gathering and analyse data, and preparing recommendations which should feed into bushmeat hunting policies in the country. PAR and PM have many applications, far beyond improving the understanding of stakeholders about complex systems (Van Velden et al., 2020; Blangy et

al., 2024). Theses processes also present opportunities for knowledge co-production and eliciting cross-sectional and longitudinal data on stakeholders' worldviews and knowledge, risk assessment, decision-making, and social learning (Quimby and Beresford, 2023).

The study also highlights the value of using mixed-methods research in understanding complex social-ecological systems such as bushmeat hunting. While there have been noteworthy shifts to incorporate social science methods into conservation practice in South Africa (Bennett et al., 2022), many researchers working in conservation lack technical skills and training when it comes to understanding and influencing human behaviour (Robinson et al., 2019). Subsequently, biodiversity conservation attempts have been hampered as social science techniques are not exploited to their full potential (Sanborn and Jung, 2021). My study shows that the integration of social science approaches into conservation practices can be invaluable, and that conservationists can gain broad insight into behavioural systems by applying a range of methodological approaches. I advocate for research on bushmeat practices and other research on natural resource use to consider both qualitative and quantitative approaches as they provided valuable context for understanding social elements of a complex system. As shown here, methods from social science disciplines, are particularly well-suited to reveal perspectives of resource users and the diverse attributes of different groups (Bennett et al., 2017).

On a more ecological level, though I used line transects to assess mammal species populations in the forests of the Eastern Cape, camera traps are still a valuable tool for assessing hunted mammal populations in forests even with increased human pressure (Dobbins et al., 2020; Cremonesi et al., 2021). Camera traps provide an unbiased and non-invasive method for monitoring wildlife populations, and their effectiveness is not compromised by human presence (Cremonesi et al., 2021). In fact, camera traps can also provide valuable insights into human activity and potential human-wildlife conflict (Dobbins et al., 2020; Cremonesi., et al., 2021). By deploying camera traps in strategic locations, researchers can gather data on mammal species presence, abundance, and behaviour, which can inform conservation and management efforts (Bersacola et al., 2022). Additionally, camera traps can be used to monitor hunting activity and identify areas of high hunting pressure, allowing for targeted conservation interventions (Deith and Brodie, 2020). While alternative methods may be more cost-effective, camera traps offer a robust and reliable approach for assessing hunted mammal densities in communal forests, making them a valuable investment for conservation and research efforts

(Deith and Brodie, 2020). The vandalism and theft of camera traps is common in open access, communal landscapes (Meek et al., 2018). Meek et al. (2018) also mentions that numerous methods have been suggested to minimize camera trap loss in these landscapes, camouflaging is one of the most used methods to deter human interference, followed by security devices such as chains and boxes. The use of decoy camera traps, shortening deployment periods, or moving away from human traffic has also been used to reduce camera trap loss (Glover-Kapfer, et al., 2019).

Understanding complex social-ecological systems like bushmeat hunting requires an integrated approach that combines insights from various scientific disciplines (Van Velden et al., 2020). By integrating these disciplines, researchers can develop a comprehensive understanding of the complex interactions between humans and wildlife, and potentially identify effective solutions to mitigate the impacts of bushmeat hunting on ecosystems and human well-being(Biggs et al., 2015; Van Velden et al., 2020). Interdisciplinary approaches are crucial for developing sustainable and equitable management strategies for complex social-ecological systems like bushmeat hunting (Biggs et al., 2015; Van Velden et al., 2020).

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Global Ecology and Conservation 17 (2019) e00583

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: http://www.elsevier.com/locate/gecco

Short Communication

Bushmeat use is widespread but under-researched in rural communities of South Africa

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ARTICLE INFO

Article history:
Received 7 December 2018
Received in revised form 28 February 2019
Accepted 1 March 2019

Keywords:
Bushmeat
Hunting
Prevalence
South Africa

ABSTRACT

Bushmeat hunting and consumption is common throughout sub-Saharan Africa. Yet, a recent review indicated that the prevalence and nature of bushmeat hunting was little researched or understood in southern African savannas. Here we present information from a number of rural livelihoods studies in South Africa that indicate that bushmeat consumption is common, with typically between 30 and 60% of rural households in the communal tenure regions stating that they consume it. Yet there are only five studies in the country explicitly investigating bushmeat hunting practices, motivations, offtake and target species. A review of the five studies indicates that bushmeat hunting is largely a male activity and that motivations and practices vary between sites. Hunting with dogs is the most common method, targeting multiple small and medium-sized species. With such widespread consumption, it is possible that bushmeat hunting may have significant effects on the population status of some target species and consequently requires urgent and in-depth research of both practices and effects.

APPENDICES

Appendix 1: Martins and Shackleton (2019), published journal article addressing the lack of knowledge on bushmeat hunting in South Africa.

Appendix 2: Ethics approval certificate

RHODES UNIVERSITY
Where leaders learn

Human Ethics subcommittee
Rhodes University Ethical Standards Committee
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NHREC Registration no. REC-241114-045

10 December 2019

Vusumzi Martins

Email: g19m9776@campus.ru.ac.za

Dear Mr Vusumzi Martins

Re: Bushmeat hunting and use in the forests of the Eastern Cape , Bushmeat hunting and use in the forests of the Eastern Cape (1065 , Dec , 2019)

Principal Investigator: Prof Charlie Shackleton

Collaborators: Mr Vusumzi Martins ,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Sincerely

Prof Joanna Dames

Chair: Human Ethics sub-committee, RUESC- HE

Appendix 3: Research Agreement with Eastern Cape Parks and Tourism Agency

APPLICATION TO CONDUCT RESEARCH ON PROTECTED AREAS

ADVENTURE PROVINCE Eastern Cape PARKS & TOURISM AGENCY

For Official Use Only			
ECPTA Project Number:	**RA 0318**	Date Received:	
Assigned to:	**Nomatile Nombewu**		

General Information
1. Applicants must complete the application form in full and attach a detailed project proposal. 2. Where research is for degree purposes, the supervisor should apply on behalf of the student and the student must be listed as a co-worker. 3. If the application is approved, the senior researcher will be required to sign a standard research agreement with ECPTA. 4. The completed application should be returned by e-mail to the Biodiversity Data Manager: Sherwyn Mack (Sherwyn.Mack@ecpta.co.za). 5. The applicant is responsible for obtaining any permits that may be required by the Eastern Cape Department of Economic Development and Environmental Affairs (DEDEA), Department of Environmental Affairs: Oceans & Coasts or the Department of Agriculture, Forestry and Fisheries (DAFF). The relevant contact details for these departments are: DEDEA (Luzuko Dali, Tel: 041-508 5800, e-mail: luzuko.dali@dedea.gov.za); Oceans & Coasts (Dr Kim Prochazka, Tel: 021 402 3546, e-mail: kimpro@environment.gov.za); DAFF (Gwen Sgwabe, Tel: 043-604 5301, e-mail: gwendolines@daff.gov.za). 6. ECPTA are responsible for the management of the following protected areas: Baviaanskloof, Beggars Bush, Commando Drift, Cycad, Dwesa- Cwebe, Dwesa-Cwebe MPA, East London Coast, Formosa, Fort Fordyce, Fort Pato, Great Fish, Groendal, Huleka, Hluleka MPA, Island, Kap River, Kowie, Luchaba, Mkambati, Mpofu, Nduli, Malekgalonyane (Ongeluksnek), Oviston, Silaka, Sunshine Coast, Thomas Baines, Tsolwana, Umtiza & Waters Meeting. Any applications for research on other protected areas should be directed to the relevant management authority.

Contact Details of Senior Researcher			
Title:	Prof	Full Name:	Charlie Michael Shackleton
Tel no:	046-603-7001	Fax no:	N/A
Cell no:	N/A	E-mail:	c.shackleton@ru.ac.za
RSA ID or Passport No: (Please attach copy)	61 11 18 5018 081	Nationality if Passport No used:	
Institution or Employer:	Rhodes University		
Postal Address:	PO BOX 94 Department of Environmental Sciences		
Physical Address:	50 Somerset St, Grahamstown, 6139		

M.f

M.E

1

Appendix 4: Household survey consent form

CONSENT LETTER

Household survey

Research title: Bushmeat hunting and use in the forests of the Eastern Cape

My name is Vusumzi Martins, a PhD candidate in Environmental Science at Rhodes University, Makhanda. I am conducting research on bushmeat hunting and use in the forests of the Eastern Cape. The goal of this study is to examine bushmeat hunting practices and how bushmeat contributes to household dietary diversity in the villages of the Eastern Cape. To achieve this goal, the following themes will be interrogated in this study: (1) assessing the livelihood benefits associated with bushmeat hunting and use, (2) determine hunting practices, (3) determine the motivations behind bushmeat hunting, (4) evaluating the direct and indirect effects of bushmeat hunting on prey populations and local landscapes and (5) assessing the sustainability of hunting in the indigenous forests of the Eastern Cape.

I am sampling six forest sites in the Eastern Cape, and two villages adjacent to each of the forest patches– one of which includes your village. Your household was randomly selected from an aerial photo depicting the entire area of this village. Participation in this study is voluntary, as such you are at liberty to decide whether or not to partake. If you agree to participate you can withdraw your participation from the interview at any stage. You are assured of anonymity in this study as the study will not link individual responses with participants identities. Your identity, physical address and any other information which may reveal your identity will not be shared with anyone else during and after the completion of the research. Moreover, permission has been provided by the local council to conduct household and hunter interviews within the village. There will be no monetary compensation to you or your family by participating in this study, be it now or in the distant future.

After completion of the research project, the outcomes will be shared through consultation meetings with the community. Brochures and pamphlets summarizing the study findings will be available to you and others deposited at community libraries. Also, presentations on the research findings may be given during some community events, such as annual general meetings, awareness campaigns and outreach activities

The current research project has been reviewed and approved by the Rhodes University ethics committee (Ethics No. 2019-1065-3178). Should you agree to participate in this study, you will be asked to sit for a face-to-face interview which takes less than an hour. The survey questionnaires will be administered to you by the researcher. The questionnaire comprises of sections, which are (1) Food security (2) Protein consumption regulatory frameworks an (3) Extraction of natural forest products questions (4) Bushmeat consumption (5) Community based natural resource management (6) General profile

Should you desire to know more about this research project and or seek further clarification, please contact my supervisors Prof. C.M. Shackleton at 046-603-7001 (tel) or Dr. A. De Vos at 046-603-7003 (tel), P.O. Box 94, Department of Environmental Science, Rhodes University, Grahamstown, South Africa. For further details with regards to ethical issues, please contact the ethics coordinator at Rhodes university Mr Siyanda Manqele at 046-603-7727 (tel).

Would you like to participate in this survey? [ ] yes | [ ] no

If yes, please append your signature below, as a way of affirming consent to participate in this research project.

Signature (Respondent)

Date signed

Appendix 5: Household survey interview form

Village name: GPS coordinates:

Date: _____ Time: _____ Interview No: _____

A) Bushmeat hunting
1. Do you or anyone in your household hunt wild animals in the forest?
2. Who does the hunting?
3. When last did they hunt?

B) Bushmeat consumption									
4. How often is bushmeat consumed in your household?									
Weekly		Monthly		Every 2-3 months		Every now and again		Never	
5. When last was bushmeat consumed in your household? And what type was it?									
6. Which species do you and your household prefer and why? 1st _____ Why _____ 2nd _____ Why _____ 3rd _____ Why _____									
7. Are there any species would you and your household never eat? If yes, what and why?									
8. Where does your household get the bushmeat?									
Buy from hunters		Personally hunt		Member of the family hunts		Eat it at another person's house		Other:	
9. Why do you eat bushmeat									
I like the taste		To supplement my diet		It is the only available source of protein		It makes me strong		For cultural reasons	
10. Is there a local bushmeat market or do hunters sell meat after hunting?									

C) Forest management
11. Are forests important to you? Why?

12. Who can go into the forest and gather natural resources?

13. Who is in charge of the forest?

Chief or headman		Community members		Government or Municipality		No one		Other:

14. Do you think the forest needs management? Why?

D) Extraction of natural products

15. What natural products do you or your household use or harvest from the forest?

Fuelwood		Grass for thatching		Wild fruits		Mammals	
Construction poles		Grass for grazing		Nuts/kernels		Insects/inverte brates	
Wood for tools or utensils		Grass for brooms or brushes		Seeds		Fish	
Carving wood		Grass for weaving		Herbs for food		Birds or bird eggs	
Plants for medicine		Wild mushrooms		Flowers		Honey or beeswax	
Reeds		Other forest products harvested:					

16. How often do you go into the forest?

Daily		2-3 times a week		Weekly		1-2 times and month		Every few months		Rarely	

17. When last did you go into the forest?

18. What is the current state of forest compared to10 years ago? Why is this so?

No change		Degraded		Better/grown	

Why:

19. Which mammal species have you personally seen or seen signs of in the forest in the last year?

Bushbuck (iMbabala)		Cape porcupine (iNcanda)	
Blue duiker (iPhuti)		Large spotted genet (iNyhwagi)	
Common duiker (iMpunzi)		Water mongoose (uMhlangala)	
Bushpig (iNgulube)		Black backed jackal (Impungutye)	
Tree hyrax (iMbila)		Caracal (iNqgawa)	

Other:

20. Are there any other species you believe or have been told are in the forest but you have never seen or heard? Please list:

E) General profile					
21. DATE:					
22. VILLAGE NAME:					
23. GPS POINT:					
24. AGE:					
25. GENDER:			MALE		FEMALE
26. OCCUPATION:					
Subsistence famer		Unemployed	Employed		Pensioner
Cattle	(Number)		Type of employment ----------		
Goat	(Number)				
Sheep	(Number)				
Chickens	(Number)				
Field crops					
Garden crops					
27. Highest level of education:					
28. Assets owned					
Car		Radio		Jojo tank	
Motorbike		Cell phone		Fridge	
Tractor		Bicycle		TV	
29. How long have you lived in the village?					
30. Number of wage earners?					
31. Does your household get government grants? What type and how many?			• Old age _____ • Disability_____ • Child _____ • Foster _____		
32. Other sources of income for the household?					
33. How many adults are there in the household? And how many are employed?					
34. How many children (≤ 16 yrs.) in the household?					

35. How many children go to school?	

Additional notes

Appendix 6: Hunter survey consent form

CONSENT LETTER

Hunter survey

Research title: Bushmeat hunting and use in the forests of the Eastern Cape

My name is Vusumzi Martins, a PhD candidate in Environmental Science at Rhodes University, Makhanda. I am conducting research on bushmeat hunting and use in the forests of the Eastern Cape. The goal of my study is to examine bushmeat hunting practices and how bushmeat contributes to household dietary diversity in the villages of the Eastern Cape. To achieve this goal, the following themes will be interrogated in this study: (1) assessing the livelihood benefits associated with bushmeat hunting and use, (2) determine hunting practices, (3) determine the motivations behind bushmeat hunting, (4) evaluating the direct and indirect effects of bushmeat hunting on prey populations and local landscapes and (5) assessing the sustainability of hunting in the indigenous forests of the Eastern Cape.

I am sampling six forest sites in the Eastern Cape, and two villages adjacent to each of the forest patches – one of which includes your village. During my initial research in your village (which involved communication with the headmen and other hunters), you have been identified as one of the hunters in the village. I would like to interview you in order to gain insights on your hunting practices, your cultural beliefs and the bushmeat market and bushmeat selling in your village or nearby town.

Participation in this study is completely voluntary. If you agree to participate you can withdraw your participation from the interview at any stage. You are assured of anonymity in this study, as the study will not link individual responses with participants identities. Your identity, physical address and any other information which may reveal your identity will not be shared with anyone else during and after the completion of the research. Moreover, permission has been provided by the local council to conduct household and hunter interviews within the village. There will be no monetary compensation to you or your family by participating in this study, be it now or in the distant future.

After completion of the research project, the outcomes will be shared through consultation meetings with the community. Brochures and pamphlets summarizing the study findings will

be available to you and others deposited at community libraries. Also, presentations on the research findings may be given during some community events, such as annual general meetings, awareness campaigns and outreach activities

The current research project has been reviewed and approved by the Rhodes University ethics committee (Ethics No. 2019-1065-3178Should you agree to participate in this study, you will be asked to sit for a face-to-face interview which take less than an hour.

Should you desire to know more about this research project and or seek further clarification, please contact my supervisors Prof. C.M. Shackleton at 046-603-7001 (tel) or Dr. A. De Vos at 046-603-7003 (tel), P.O. Box 94, Department of Environmental Science, Rhodes University, Grahamstown, South Africa. For further details with regards to ethical issues, please contact the ethics coordinator at Rhodes university Mr Siyanda Manqele at 046-603-7727 (tel).

Would you like to participate in this questionnaire? [ ] yes | [ ] no

If yes, please append your signature below, as a way of affirming consent to participate in this research project.

…….. .. ……

Signature (Respondent)

Date signed

Appendix 7: Hunter survey interview form

Village name: _____ GPS coordinates: _____

Date: _____ Time: _____ Interview No: _____

A) Bushmeat hunting											
1. How long have you been hunting?											
2. At what age did you start hunting?											
3. Who did you learn from?											
4. Would you want your children to hunt? If so, Why?											
5. How often do you hunt?											
Daily		Weekly		Monthly		Every 2-3 months		Irregularly			
6. What day/days of the week do you usually hunt?											
7. Why do you hunt? (can tick more than one option)											
To feed my family		Sport/Competitive		Recreational		Cultural		Income			
8. Which time of day do you typically hunt? And why?											
Dawn		Dusk		Day time		Night-time		Anytime of the day			
9. Where do you usually hunt? a) b) c)											
10. How do you decide where to hunt (what criteria do you use)?											

11. How long (time period) is your typical hunting trip?

12. Which species do you target when you hunt?

1st _____
2nd _____
3rd _____
4th _____
5th _____

13. Which species do you catch most often?
a)
b)
c)

14. Which hunting methods do you use? And why? (can tick more than one option)

Snares		Dogs		Guns		Other ……

Why:

15. Does how much and what you catch vary with season, moon phase or time of day? If yes, how?

16. Who in the village does most of the hunting?

Young boys		Teenagers		Adults		Older men		

17. Have you ever seen, or know of, any hunters not from your village hunting in the forest? If so,

How often?	Where do they come from?	What hunting methods do they use?

18. What influence people's willingness to hunt?

19. Do you hunt alone, with others or both?

20. If with others, usually who and how many?

21. What do you do with the prey you catch? (can tick more than one)

Sell		Eat in forest		Take home	

If more than one, which do you do the most and which is the least?

Most _____

Least _____

22. If take home, who cooks it? And who eats it?

23. Do hunters share knowledge about best hunting sites and techniques? Why?

24. Do you think that over the last 10 years the number of hunters in your village has:

Declined		Remained the same		Increased	

Why?

25. Do you think in the last 10 years the amount of hunting in the local forest has:

Declined		Remained the same		Increased	

Why?

26. Over the past 10 years which mammal species in the forest have increased, and which have decreased or have stayed the same?

	Increased	Remained the same	Decreased
Bushbuck (iMbabala)			
Blue duiker (iPhuti)			
Common duiker (iMpunzi)			
Bushpig (iNgulube)			
Tree hyrax (iMbila)			
Cape porcupine (iNcanda)			
Large spotted genet (iNyhwagi)			
Water mongoose (uMhlangala)			
Black backed jackal (Impungutye)			
Caracal (iNqgawa)			
Other species:			

27. Do you think hunting is sustainable in this forest?

Yes		No		Don't know	

Why?

28. How many hunting trips did you conduct in the last year (last 12 months)?

29. Of those trips, how many did you catch prey and how many did you come back empty handed?

30. Which hunting methods did you use?

31. If more than one, which method was the most successful hunting method?

B) Cultural beliefs

32. Which species do you consider as having cultural significance? Why?

a)
b)
c)

33. Which species are considered as being taboo? Why?

34. Are there any species that should not be consumed by certain genders or age groups? Why?

35. Which, if any, cultural ceremonies or practise require bushmeat?

36. Do hunters have any special regard in the community? If yes, why?

37. Which, if any, hunting methods are culturally not accepted?

(C) Bushmeat market and selling

1. Which, if any formal bushmeat markets existing the village or surrounding area?

2. Do you sell the meat you catch?

3. What portion of the meat do you sell?

0		1-25%		26-50%		51-75%		76-100%

4. Which species are mostly wanted by your customers?

1st _____
2nd _____
3rd _____
4th _____
5th _____

5. Where and to whom do you sell?

6. Do people pre-order?

7. How do you price the meat?

Species 1_____ Price_____
Species 2_____ Price_____
Species 3_____ Price_____
Species 4_____ Price_____
Species 5_____ Price_____

8. Is there a particular time of the month or year when you get more orders than usual? Why?

9. Approximately how much do you earn per month from selling bushmeat?

<R200		R201-R500		R501-R1000		R1001-R3000		>R3000	

10. What do you do with the money you get from selling bushmeat?

11. Do you consider bushmeat hunting as a lucrative business? Why?

(D) Last hunting trip

1. When was your last successful or unsuccessful hunting trip?

2. Where did you hunt?

3. Who were you with?

4. Why did you go hunting on that particular day?

I/we always hunt on that day of the week or month		There was no meat at home		I/we needed money		No particular reason		Other:

5. Which hunting method/s did you use?

Snares		Dogs		Guns		Other…….

6. What time did you start and finish hunting? (Duration of hunting trip)

7. How was the weather on that particular day?

8. Did you catch anything? What?

9. What did you do with the catch?

Sell		Eat in the forest		Take home		Other:

10. How did you feel about your hunting trip on that day? Why?

(E) Hunter profile							
38. DATE:							
39. VILLAGE NAME:							
40. GPS POINT:							
41. AGE:							
42. GENDER:				MALE		FEMALE	
43. OCCUPATION:							
Subsistence famer		Unemployed		Employed		Pensioner	
Cattle	(Number)			Type of employment ----------			
Goat	(Number)						
Sheep	(Number)						
Chickens	(Number)						
Field crops							
Garden crops							
44. Highest level of education:							
45. Assets owned							
Car		Radio		Jojo tank			
Motorbike		Cell phone		Fridge			
Tractor		Bicycle		TV			
46. How long have you lived in the village?							
47. Do you or people in your household get government grants? What type and how many?				• Old age _____ • Disability _____ • Child _____ • Foster _____			
48. Other sources of income?							
49. How many adults in your household? And how many are employed?							
50. How many children (≤16 yrs.) in the household?							
51. How many children go to school?							

Additional Notes