



The Role of Traditional Ecological Knowledge in Managing the Collection of Non-Timber Forest Products in Limpopo, South Africa: A Community-Based Resource Governance Approach

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Abstract

I aimed to evaluate the role of traditional ecological knowledge (TEK) in managing the collection of non-timber forest products (NTFPs) in Muyexe and Matiyane, located in Limpopo Province, South Africa. To do this, I gathered data from tribal authorities and local communities through semi-structured face-to-face interviews, involving a total of 148 respondents from both villages. Participants were selected using a combination of purposive and snowball sampling methods. Data were analyzed with thematic content analysis. My study identified two main categories of TEK used in managing NTFP harvesting: TEK in the form of rules and regulations, and TEK in the form of taboos. The enforcement of laws and sanctions for violations emerged as the most important factor affecting the effectiveness of local institutions in managing NTFP collection. I emphasize that, beyond modernization, agreed-upon rules and taboos governing resource collection play vital roles in conserving mopane trees (*Colophospermum mopane*) and marula trees (*Sclerocarya birrea* subsp. *caffra*). The findings suggest a need for adaptable local management systems that strengthen TEK among communities involved in managing or overseeing NTFP collection, thereby promoting long-term livelihood security and conserving marula and mopane woodland communities.

Keywords Common Property · Communal Land · Communities or Villagers · Local Institutions · Natural Resources · Property Rights · Limpopo · South Africa

Introduction

Communities worldwide that rely on forests depend on non-timber forest products (NTFPs) to support themselves and preserve their cultural identities. Although NTFPs have been collected or harvested for hundreds of years, they were studied and acknowledged by scholars and the scientific community by the 1980s. Different terms such as natural products, wild products, veld products, non-timber forest and grassland products, and sustainably produced wood products have been used in literature (Sorrenti, 2017). While terminology varies by region, NTFPs are generally

used to describe non-timber products gathered from forests. NTFPs include “biological products (i.e., not abiotic products or ecosystem services), wild species (indigenous, naturalized, or alien), harvested by humans (excluding fodder eaten by free-ranging animals) for both consumption and non-consumption purposes from any landscape or ecosystem (including human-dominated ones)” (Shackleton et al., 2011, p. 16). This category covers wild plants, fungi, and animal products collected or caught from various habitats for items like firewood, wild fruits, nuts, edible roots, small mammals, insects, fish, honey, palms, and medicinal plants, used for household consumption or small-scale trade (Pul-lanikkatil & Shackleton, 2019). Therefore, NTFPs serve as a form of ‘green social security’ for communities by providing food supplements, traditional medicines, fuel and fodder, affordable building materials, decorations, arts and crafts items, and sources of employment and income (Pandey et al., 2016).

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Although the number of NTFP users varies by location, Shackleton and De Vos (2022) estimated that approximately 5.6 billion people worldwide, in both rural and urban areas across developed and developing countries, depend on various NTFPs to satisfy multiple livelihood needs. This includes collecting products for subsistence and cultural reasons (Djeukam et al., 2022), generating cash income, and supplementing or diversifying income sources (Angelsen et al., 2014; Leßmeister et al., 2018; Derebe & Alemu, 2023). The use of NTFPs has also contributed to reducing poverty in many regions globally (Dou et al., 2023). Over the past 20 years, research on environmental income has grown, with NTFPs representing a significant portion of this body of work. Data from the Poverty Environment Network (PEN) project, which examined 24 countries across Sub-Saharan Africa, Asia, and Latin America, revealed that an average of 22.2% of household income (both cash and non-cash) originated from NTFPs (Angelsen et al., 2014; Pullanikkatil & Shackleton, 2019). Mugido and Shackleton (2019) also analyzed income surveys from 1200 households in South Africa, finding that the average income share from NTFPs was 15% when social grants were included as income, or 30% when social grants were excluded. Therefore, NTFP income plays a crucial role in supporting both rural and urban households.

I focus on two NTFPs: marula fruits in Matiyane and mopane worms in Muyexe. As a result, marula trees dominate Matiyane, while mopane trees are the most common in Muyexe—both are essential for the livelihoods of most people in these villages. Most residents depend on marula fruits in Matiyane (Sinthumule & Mzamani, 2019), while the majority in Muyexe rely on mopane worms as a livelihood (Sinthumule, 2024a, b). Traditionally, marula fruits were harvested for household use. However, over the past twenty years, the harvesting of marula fruits has shifted from subsistence to commercial purposes, as seen in Swaziland (Murphy & Pelter, 2018), Zimbabwe (Mguni et al., 2023), and South Africa (Sinthumule & Mzamani, 2019). Therefore, harvesting marula fruits plays a vital role in the lives and livelihoods of local communities. For example, in the Beitbridge district of southern Zimbabwe, marula contributes 35% to family income (Mguni et al., 2023).

Recent studies in Zimbabwe (Manditsera et al., 2022), Namibia (Togarepi et al., 2020), Botswana (Mogomotsi et al., 2018), and South Africa (Sinthumule, 2025) have shown that mopane worms are harvested for household consumption and trade. Selling mopane worms has become a significant business venture. There are also thriving cross-border networks involved in the mopane worm trade. For example, Sekonya (2022) reported active cross-border mopane trade between Botswana and South Africa, while Thomas (2013) documented a lively trade between Namibia and Angola.

This shows that these NTFPs are no longer only important for household use but also for commercial purposes. Increasing demand for the commercial trade of NTFPs has led to the harvest of larger quantities from wild plant populations, raising concerns about over-exploitation (van den Boog et al., 2018). For instance, several plant species are harvested excessively and intensively; in some cases, collectors cut plants too young or too close to the ground. Such practices inhibit re-sprouting, disrupt ecosystem balance, decrease the number and population of species, and contribute to species depletion, which may potentially lead to extinction (Muler et al., 2014). This indicates that many NTFPs will need some form of management to withstand heavy harvesting pressure (Upreti et al., 2016). Traditional ecological knowledge (TEK) has also become a valuable tool for managing the harvesting of NTFPs.

Berkes (2017) described TEK as “a cumulative body of knowledge and beliefs, handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment.” This knowledge system is dynamic, evolving, culturally embedded, and contextually specific (Boafo et al., 2016), and it is rooted in social institutions such as customary rules, regulations, prohibitions, and sanctions (Sinthumule & Mashau, 2020). For example, Hutaeruk et al. (2018) studied NTFPs from Setulang Village Forest based on the local knowledge of the Uma Longh community in Indonesia. Additionally, Min et al. (2024) examined the current state and trends of research on TEK related to NTFPs as food. Despite the research on TEK and NTFPs, managing the harvesting of NTFPs remains an issue, especially in communal areas. For instance, managing the harvest of mopane worms in communal lands in Zimbabwe (Mufandaedza et al., 2015) and Namibia (Thomas, 2013) continues to be challenging because local institutions are weakened. Similarly, fisheries harvesting in the Kafue Flats in Zambia has caused conflicts and overharvesting of fish, mainly due to the erosion of local institutions (Haller et al., 2016).

I aimed to investigate the role of TEK in managing the harvesting of mopane worms and marula fruits (NTFPs) in Muyexe and Matiyane. The specific objectives are to (a) understand the management institutions overseeing NTFP harvesting and (b) explore the methods used by local people for harvesting NTFPs. To achieve these goals, Muyexe and Matiyane, which have a high dependence on subtropical deciduous woodlands, were selected as case studies. In today’s modernized world, which heavily relies on formal education, I emphasize the importance of TEK (informal knowledge) in managing NTFP harvesting. It is also essential for governments and policymakers to recognize local knowledge as a valuable resource for NTFP management. Documenting and analyzing TEK not only helps improve

governance structures but also guides harvesting practices and supports community-based natural resource management. Since both villages are under communal ownership, resources are viewed as common property of the local communities.

Theoretical Perspectives on Common Property Regimes in Resource Management

There are four different types of property regimes identified in the literature: open access, public or state property, common property, and private property (Moritz et al., 2013). Of particular interest here are common property resources (CPRs)—a term used to describe natural resources accessible as commons (Lozny, 2023). Muñoz-Arriola et al. (2021: 1) defined CPRs as “a consumable resource where it is difficult to exclude users and where one person’s use depletes the pool for others.” In other words, CPRs are accessible to more than one person (Moritz et al., 2013; Lozny & McGovern, 2019). They include common forests, pasturelands, wells, fisheries in national waters, and irrigation systems (Acheson, 2015; Lozny & McGovern, 2019). In southern Africa, including South Africa, these CPRs are primarily held on common property within communal lands. While common property resources are located on communal land, they are not everyone’s property; instead, they are owned by an identified group of people who have the right to exclude non-owners (non-residents) (Ciriacy-Wantrup et al., 2019). Such communities are responsible for maintaining the property through restrictions on its use (Libecap, 2025). Therefore, common property resources belong to a specific group or community of co-equal owners, with access rules and regulations established based on community membership. Unlike open access resources, which are available to all and where no one has the legal right to exclude others from using them (Acheson, 2015; Lozny & McGovern, 2019), members of a particular community in common property regimes have the legal right to exclude non-members (Ciriacy-Wantrup et al., 2019; Libecap, 2025). This means a designated user group of coequal owners holds use rights over resources within their jurisdiction. The tribe, the village, the clan or lineage, user committees, cooperatives, the municipality, or the local government can hold such property rights. Landowners within the territory where the resource exists are responsible for establishing, monitoring, and regulating broad-scale management goals, while the benefits from the resource’s direct or indirect use support local livelihoods and wellbeing (Shackleton et al., 2011).

Property rights are social institutions that grant individuals legal ownership of specific assets (Ramutsindela

& Sinthumule, 2017; Lozny & McGovern, 2019). In this context, legal ownership allows the owner to control and utilize resources as they see fit and to prevent others from using them (Egan & Place, 2013). Property owners also have the authority to decide, oversee, and manage the land and its resources (Lozny & McGovern, 2019). Institutions are systems of social rules that shape interactions within a particular environment through regulations, principles, and guidelines (Heclo, 2018). Therefore, social institutions foster cooperation and collective action, reduce transaction costs (Carballo & Feinman, 2016), and help limit resource use, promote sustainable practices (Lozny & McGovern, 2019; Lozny, 2023), and coordinate resource users (Sikor et al., 2017). While social institutions offer important benefits, potential free-rider problems must be addressed to enable communities to manage resources effectively. Outsiders can encroach on and exploit resources if enforcement, rules, and regulations are weak or absent (Thomas, 2013; Mufandaedza et al., 2015). Additionally, conservation rules and regulations may or may not be established within common property regimes, leading to either ‘regulated’ (Libecap, 2025) or ‘unregulated’ (Karpoff, 2022) common property.

On one hand, regulated common property has established access and conservation rules and regulations (Madani & Dinar, 2013). On the other hand, unregulated common property resources are only protected by community membership restrictions—conservation rules and regulations either do not exist or are not enforced (Karpoff, 2022). Unregulated common property is vulnerable to overharvesting and may cause resource degradation if the user group is large relative to the resource or if income from resource exploitation is high compared to the opportunity cost of time (Lozny & McGovern, 2019; Karpoff, 2022). Understanding social institutions, such as property rights, in the context of common property resources under communal ownership is important because they can determine whether resource harvesting is sustainable. The presence of conservation rules or institutions governing resource use on communal land can be seen as a prerequisite for sustainable harvesting. Conversely, the absence of such rules or enforcement can pose a threat, potentially leading to overuse and resource depletion.

Methodology

Study Area

The study took place in the Limpopo province of South Africa, specifically in Muyexe (23°11′42.4″S, 30°54′57.49″E) and Matiyane (22°44′37.38″S, 30°58′18.90″E). Muyexe is part of the Greater Giyani Local Municipality (Mopani District Municipality), while Matiyane falls under Collins Chabane

Local Municipality (Vhembe District Municipality). The towns of Matiyane and Muyexe are roughly 79 km apart, situated on the eastern border of Kruger National Park (KNP). Muyexe is the last village before entering KNP through Shangani gate, while Matiyane is the final village before entering KNP via Phunda Maria gate (Fig. 1).

The two villages share many similarities, but a significant difference is that, unlike Matiyane, which is unfenced, Muyexe is enclosed by a fence designed to prevent the spread of diseases from wildlife in the park to domestic animals on communal land. Both Muyexe and Matiyane are located on communal land managed by the Muyexe and Mhinga Tribal Authorities, respectively. The local chiefs oversee land management, a crucial role since residents depend heavily on their land for essential goods and daily livelihoods. Matiyane covers 3.62 km² and has a population of 3,073 people living in 809 households, while Muyexe spans 3.42 km² with 3,228 residents across 900 households (Census, 2011). Population figures may have changed since then, as the data is from 2011. There are no immediate job opportunities in Matiyane (Sinthumule & Mzamani, 2019) or Muyexe (Mathebula, 2014). Limpopo province

faces high unemployment rates; about 60.4% of residents in Muyexe are unemployed, and between 60% and 80% in Matiyane (Chaminuka et al., 2012). These figures may have shifted since the unemployment data was collected in 2012 and 2013. As a result, residents mainly rely on government grants (such as pensions and child grants) and remittances from relatives (Chaminuka et al., 2014). Land uses in Matiyane include human settlement, harvesting of NTFPs, livestock farming, and subsistence agriculture (Chaminuka et al., 2012; Sinthumule & Mzamani, 2019). Conversely, land use activities in Muyexe include livestock farming, settlement, hunting, and harvesting NTFPs. According to Shamuyarira (2017), Matiyane has a semi-arid climate with an average daily maximum temperature of about 28 °C and annual rainfall of 450 mm, often experiencing long drought periods (Chaminuka et al., 2012). Muyexe is also semi-arid, with daily temperatures Ranging from 22° C to 33° C and annual rainfall between 200 and 450 mm, mostly during summer (October to March) (Jovanović et al., 2023). Both villages are located in the savanna biome, which is the largest biome in South and southern Africa (Mucina & Rutherford, 2006). Although Muyexe and Matiyane are

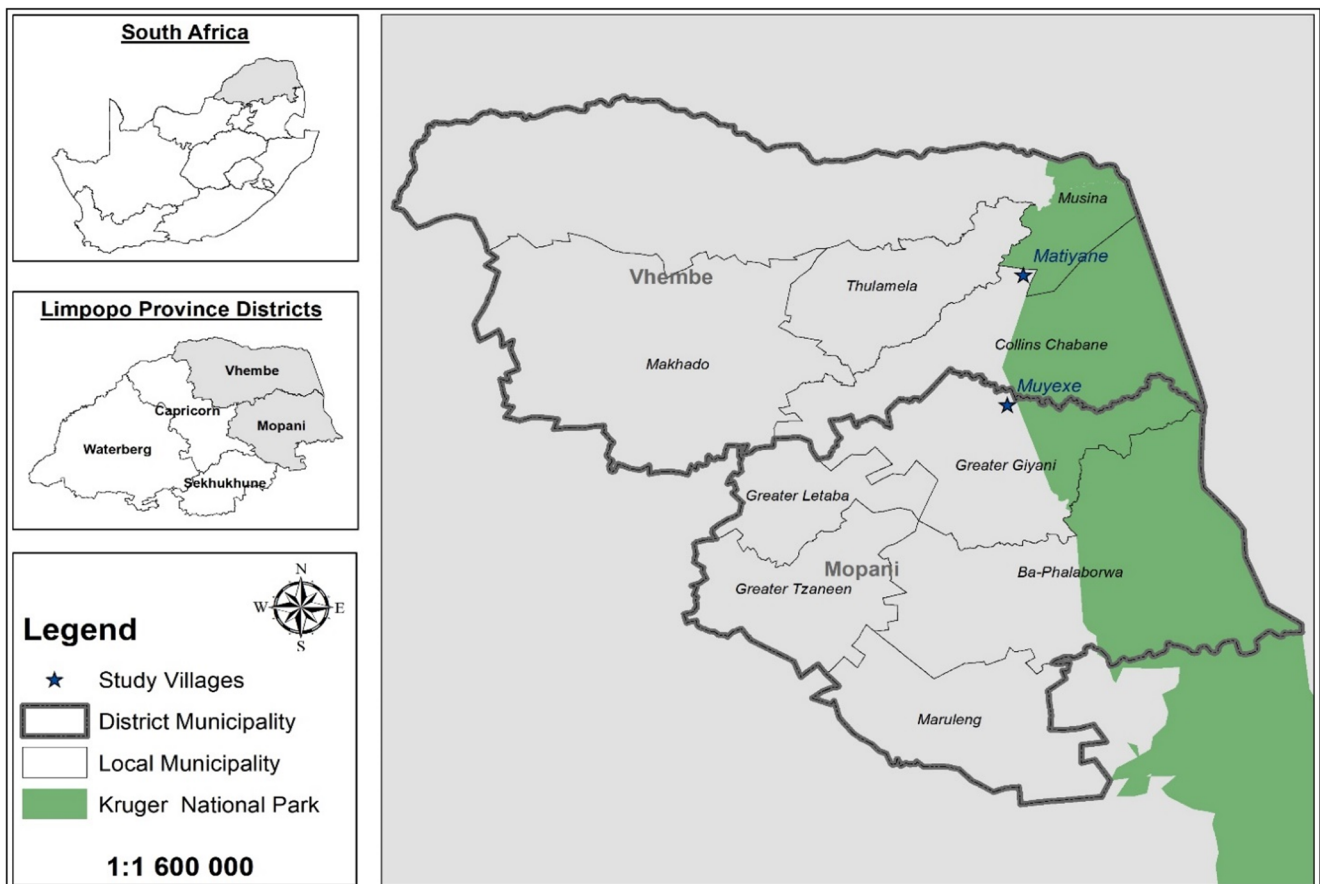


Fig. 1 Location of Muyexe and Matiyane (within Mopani and Vhembe District Municipalities, respectively) in Limpopo, South Africa. (Source, Author).

in different districts, they were both chosen because each has tribal officers responsible for patrolling and monitoring human activity within their villages. This makes these two villages unique, as other villages do not have tribal officers patrolling their areas.

Data and Methods

This research project was registered and approved by the Faculty Ethics Committee at the University of Johannesburg (Ethics Reference Number: 2022-11-18/Sinthumule). Authorization to conduct this research was also obtained from local authorities (chiefs) in Muyexe and Matiyane. Community members were asked for permission before being interviewed, and those who agreed were asked to sign a consent form. Participants were recruited through a combination of purposive and snowball sampling. The main reason for using purposive sampling was to select only individuals involved in institutions governing NTFPs. Snowball sampling was also employed. In line with Braun and Clarke (2021), interviews continued until data saturation was reached, meaning no new information was emerging. In total, 148 respondents participated in this study.

Data was collected through semi-structured face-to-face interviews conducted between June 2023 and March 2024. Semi-structured interviews were chosen because of their flexibility, which allows for open dialogue (Al Balushi, 2016). Additionally, this interview format enables researchers to follow up on unclear answers (Adams, 2015). The semi-structured interviews targeted local traditional leaders (key informants) in each village and individuals involved in harvesting mopane worms and marula fruits. The questions directed at local traditional leaders covered biographical information, their role in managing NTFPs, existing management institutions overseeing NTFP harvesting, and sanctions for violators. Harvesters were asked about their knowledge of the National Forests Act, 1998, harvesting seasons, methods used for gathering NTFPs, and whether harvesting practices were sustainable—meaning social behaviors and actions that prevent degradation or destruction of marula and mopane woodlands. The interviews were conducted verbally in Tsonga (the local language) by a researcher and two native-speaking research assistants who received two days of training on conducting interviews. Each interview lasted about 80 min on average. The interviews took place during weekdays, from Monday to Sunday, between 9:00 a.m. and 5:00 p.m.

The data collected were analyzed using thematic content analysis. In line with Bernard (2017), data collection and analysis were conducted simultaneously. To better understand the data, the researcher carefully reviewed the transcribed notes in the evening. Microsoft Excel was used to

compile the interview extracts from respondents, with key phrases highlighted in different colors according to categories. Following Bernard (2017), the data were then grouped by codes, providing a clear overview of the main points and recurring themes throughout the data. The next step was to identify patterns among the codes. From these patterns, two themes aligned with the research objectives emerged: management institutions governing NTFP harvesting and harvesting methods for NTFPs. In some cases, episodes and events were described in the exact words used by respondents to give readers a deeper understanding of the conditions examined, without altering what was recorded. The direct quotations support and clarify the relevance and contribution of the research findings.

Results and Discussion

Characteristics of Communities

All respondents were Tsonga-speaking individuals. The five key respondents—local traditional leaders—interviewed in Muyexe and Matiyane were all men, each over 50 years old. Three were employed, while two were unemployed and had completed secondary education. Of the 67 respondents interviewed in Matiyane, 63 were women and only four were men; in contrast, in Muyexe, 72 were women and six were men. Therefore, most people involved in NTFP collection were women. The majority of respondents—51 in Matiyane and 47 in Muyexe—were over 50 years old (see Table 1).

The youngest participant in Matiyane was 44, and the oldest was 72. Similarly, in Muyexe, the youngest was 34, and the oldest was 76. Regarding employment, most respondents interviewed ($n=65$; $n=76$) in Matiyane and Muyexe were unemployed at the time of the study. As a

Table 1 The socioeconomic profile of the respondents in Matiyane and muyexe.
(Source, Author).

Categories	Class	Matiyane ($n=67$)	Muyexe ($n=78$)
Age	18–30 years	00	03
	31–40 years	03	09
	41–50 years	13	18
	51–60 years	43	34
	> 61 years	08	13
Gender	Male	04	06
	Female	63	72
Education	None	12	11
	Primary	17	28
	Secondary	38	36
	Tertiary	00	03
Occupation	Unemployed	65	76
	Employed	00	02

result, they relied on NTFPs as a short-term income source. Besides NTFPs for livelihoods, respondents in both Matiyane and Muyexe also depend on child and pension grants from the government and remittances from household members who do not live locally. The main NTFP activities in Muyexe include harvesting mopane worms, medicines, and wood from mopane trees. Conversely, in Matiyane, the primary NTFP activity involves harvesting marula fruits from *Sclerocarya birrea*. NTFPs are mainly sold locally and within Limpopo province. Other significant land use activities tied to the communities in both Matiyane and Muyexe include livestock rearing and subsistence farming, with maize as the main crop.

Management Institutions Governing the Harvesting of NTFPs

At the national level, indigenous forests and trees in South Africa are protected by the National Forests Act of 1998 (Act No. 84 of 1998). The purpose of this Act is, among other things, to provide special measures for protecting trees and forests and to promote the sustainable management and development of forests for everyone's benefit (South Africa, 1998). The measures for protecting trees in South Africa are outlined in Sect. 12 of the National Forests Act, which allows the Minister to declare a tree, woodland, or species of tree as protected. Under this legislation, the proposed list of protected tree species includes *Sclerocarya birrea* subsp. *caffra* (National Tree Number 360). While Sect. 15(1) of the National Forests Act states that no one may cut, disturb, damage, destroy, or remove any protected tree, it does not address the harvesting of wild fruits or NTFPs from protected trees. According to Sect. 62(2)(c), anyone who violates the ban on cutting, disturbing, damaging, destroying, or removing protected trees may face fines or imprisonment (South Africa, 2019). Similarly, in Namibia, Wynberg et al. (2013) found that wild fruit trees, including marula trees, are regulated by the Forest Act (12 of 2001). This Act prohibits felling, destroying, or removing fruit trees without prior permission. Although *Colophospermum mopane* is not listed as a protected species, its indigenous status in South Africa effectively provides it with protection. According to the National Forests Act, *Sclerocarya birrea* and *Colophospermum mopane* are important species in South Africa that should be protected wherever they grow because they are native. This means that the *Sclerocarya birrea* in Matiyane and *Colophospermum mopane* in Muyexe are protected under this Act.

Respondents were unaware of the National Forests Act, 1998 (Act No. 84 of 1998), and its role in tree and forest conservation. They also did not know that government officials enforce the National Forests Act No. 84 of 1998.

They mentioned that they rarely see any government officials—either from the municipality or from Environmental Affairs—in both Matiyane and Muyexe. Although environmental policy and legislation are based on strong democratic principles, their implementation and enforcement were found to be lacking in the study area, as reported by other scholars (Howes et al., 2017). For example, a lack of capacity clearly emerges as a problem in implementing and enforcing environmental policies and laws (Sinthumule, 2024a, b). Therefore, even though policies exist to protect *Colophospermum mopane* and *Sclerocarya birrea*, these laws are poorly carried out and enforced by both national and local government officials. As Ole et al. (2024) noted, there is also a lack of political will within the government to enforce compliance, especially in developing countries. Similar studies elsewhere, which align with the findings from this study, have identified gaps in policy implementation and enforcement. This issue is particularly significant in developing nations such as Ghana (Mensah et al., 2023), Brazil (Aklin et al., 2014), and China (Ran, 2017). These gaps have serious consequences for environmental protection and resource conservation.

At the local level, *Colophospermum mopane* and *Sclerocarya birrea* are protected by customary systems enforced by headmen and chiefs. Customary systems are “a code of conduct approved by tribal tradition, the hereditary body of established conduct, taboos, and belief systems that have been observed, recognized, and enjoyed from time immemorial, and handed down by the forefathers” (Kozanayi et al., 2014, p. 246). As noted, both Muyexe and Matiyane are communal lands falling under Chief Muyexe and the Matiyane headmen (the Mhinga Tribal Authority), respectively. Both areas have traditional council members appointed by their respective chiefs. Their responsibilities include managing the affairs of the traditional community according to customs and traditions, supporting and guiding traditional leaders in their roles, participating in the development of policy and legislation at the local level, and promoting TEK for sustainable development and disaster management. The standard customary rules, regulations, and taboos (TEK) used in the study area are listed in Table 2.

Customary rules and regulations have been established for the effective governance and management of NTFPs in both Matiyane and Muyexe. Although there is a lack of implementation and enforcement of the national policies governing forests and indigenous trees in the study area, this study found that enforcement by local institutions plays a significant role in managing NTFP harvesting. Unlike in the study area, where customary rules and local institutions remain effective in managing NTFP collection, in the communal areas of the Eastern Cape, South Africa, democracy and changing political and social contexts have worsened

Table 2 Widely applied customary rules and regulations as well as taboos in the studied communities

	Muyexe (Mopane Worms)	Matiyane (Marula Fruits)
Access to the area	• Free for locals and a daily permit of R100 for non-locals. • Cars for non-locals pay an entrance fee of R100.	• Free for locals and permission required for non-locals.
Harvesting rules	• No harvesting of mopane worms until the chief announces the start of the harvesting season. • No harvesting of non-villagers without a permit • No harvesting of juvenile worms • No climbing of trees when harvesting • No cutting of trees when harvesting • Digging pupae is considered taboo and strictly forbidden. • No limitation on the mopane worm harvested.	• No climbing of trees when harvesting fruits • No cutting of tree branches when harvesting fruits • No cutting of trees when harvesting fruits • Cutting marula trees (fruit tree) is considered a taboo and strictly forbidden. • No limitation on fruits harvested.
Enforcement of rules and regulations	• Tribal officers • Constant monitoring • Sanctions for offenders and confiscation of harvest	• Tribal officers • Constant monitoring • Sanctions for offenders and confiscation of harvest

resource management problems and led to the erosion of traditional authorities' roles (Bennett et al., 2013). Consequently, civil society institutions such as ward councilors, who are democratically elected, tend to have broader community appeal than traditional leaders like headmen and Chiefs. As a result, they are increasingly responsible for most management activities, even though they lack direct mandates over natural resources (Bennett et al., 2013). The absence of enforcement of customary systems was found to have profound implications for NTFP management. The situation in other southern African countries also differs; for example, although local institutions exist in Namibia, they are not enforced, and a lack of monitoring by tribal officials renders them ineffective in managing mopane worm harvesting. Despite this, illegal harvesting of mopane worms remains widespread due to poor enforcement and monitoring systems (Thomas, 2013). Rules for mopane worm harvesting in Mwenezi resettlement areas and Chikombedzi communal area in Zimbabwe were also found to be either weak or absent, leading to unsustainable harvesting (Mufandaedza et al., 2015). Similarly, in the Kafue Flats of Zambia, fish harvesting has caused conflicts and overexploitation of fish resources, which is linked to the erosion of local institutions (Haller et al., 2016). Therefore, having social

institutions alone is not enough; these institutions must be enforced and monitored to ensure sustainable harvesting practices.

I also found that customary rules and regulations protect or support the harvesting of NTFPs by communities. For example, only Muyexe communities are allowed to harvest mopane worms (NTFPs) during mopane season. Therefore, even though Muyexe is a communal land area, mopane worm harvesting is not open to everyone; local institutions regulate it. Unlike open-access resources, where anyone can access them without restrictions (Acheson, 2015; Lozny & McGovern, 2019), in Muyexe—a regulated common property—local communities and their leaders have the legal right to exclude outsiders (Ciriacy-Wantrup et al., 2019). People from other villages are not permitted to harvest mopane worms unless they pay an entrance fee of R100 (US\$5.31), after which they receive a one-day permit and must follow the village's rules, including protecting the mopane woodlands. It was reported that during the harvesting season, a vehicle from outside the community is charged a fee of R100 (US\$5.31) to enter the village. These findings align with Gondo et al. (2017), who noted that some rural district councils in Zimbabwe have already imposed a levy on traders from outside the district harvesting mopane worms. While local community members in Muyexe do not pay for harvesting mopane worms, in Namibia, harvesters are required to buy a permit from the Uukwaluudhi traditional authority, costing US\$2.86 for residents and US\$5.71 for non-residents (Thomas, 2013). Similarly, Mogomotsi et al. (2018) reported that communities in Botswana also need to have a license to harvest mopane worms. Although traditionally harvested for household consumption, over the past 30 years, mopane worm harvesting has become a crucial source of livelihood for communities. This is not unique to Muyexe; literature indicates that mopane worm harvesting is an important livelihood activity across southern Africa (Bara et al., 2022; Manditsera et al., 2022). As Sinthumule and Mzamani (2019) observed, in times of economic hardship and poverty, rural people increasingly depend on natural resources to generate income.

I also found that cutting wet *Colophospermum mopane* for fuelwood is strictly prohibited. However, local communities residing within Muyexe are allowed to harvest dry *Colophospermum mopane* for fuelwood, while people from other villages are not permitted to harvest wood within the village, aligning with the principle of regulated common property resources that exclude non-members (Libecap, 2025). In this context, this type of property regime (regulated common property) functions to limit use and coordinate users, which is important for managing mopane worms (Mufandaedza et al., 2015). The analysis of interview data showed that harvesting dry mopane wood is only allowed

for subsistence, not for commercial purposes. These findings contrast with other studies in southern Africa, where mopane woodlands can be harvested for both subsistence and commercial uses. For example, commercial harvesting of mopane wood in Mozambique (Foloma, 2004), Namibia (Mapaure, 2011), and Botswana (Teketay et al., 2018) has led to the destruction or degradation of mopane woodlands due to unsustainable practices. Consequently, concerns are growing about the decline of mopane woodland caused by overharvesting, especially for firewood. Therefore, unregulated harvesting of NTFPs is vulnerable to degradation or destruction because of the absence of rules and regulations (Karpoff, 2022) and may lead to Garrett Hardin's 'tragedy of the commons'.

Since commercial harvesting of mopane wood is banned in the study area, residents are not allowed to transport harvested wood outside of Muyexe. As one respondent stated:

Cutting wet mopane wood is not permitted. We uphold this rule because mopane trees are a vital source of livelihood. Mopane worms harvested from these trees also provide income for many people in this village. We watch out for people from other villages who come to cut mopane wood for commercial use. (#Interview, community member, 2023)

This regulation is enforced by the council members and the communities themselves, and those who violate it are fined. Many community members interviewed mentioned that they are poor and unemployed, so they follow the rules because they cannot afford fines. As a result, there have been no incidents of fines for rule violations over the past five years. This rule has played a key role in protecting mopane trees in the area. As observed, Muyexe has an entrance gate, a security guard, and is surrounded by a fence to control the spread of diseases from wildlife in the park to domestic animals in communal lands; this makes enforcing the regulation easier, especially for outsiders wanting to access village resources. In the case of Matiyane, specific rules and regulations facilitate the collection of NTFPs. For example, only the Matiyane community is allowed to harvest marula fruits during the season. People from other villages must first get permission from the tribal authority to harvest marula fruits. Similar permission rules apply in communal lands of Makhatini and Bushbuckridge in South Africa, Mukwakwe in Zimbabwe, and Namibia (Tapiwa, 2019). I also found that there are taboos linked to fruit trees. Taboos are broadly defined as a 'prohibition imposed by social custom or as a protective measure' (Colding & Folke, 2001, p. 584). They are social institutions passed down orally from generation to generation, with no written rules, where social customs regulate human behavior. Additionally, they are self-imposed,

self-monitored, challenging to change, and are often communicated through the imperative 'you shall not' (Negi, 2017; Cleaver, 2017). Traditionally, cutting a marula tree (male or female) or any fruit tree is taboo and strictly forbidden. As one community member stated:

In our culture, it is taboo to cut fruit trees. This traditional knowledge has been passed down from one generation to the next. Marula trees, whether male or female, can only be cut with the chief's permission. This also applies to a marula tree in your own yard (#Interview, community member, 2024).

This is because fruit trees provide food for people and are also a source of livelihood for many poor and unemployed individuals. As Tapiwa (2019) noted, cutting fruit trees is not allowed and is generally regarded as a taboo in southern Africa. In this sense, such taboos protect marula fruit trees and help ensure food security for communities. Although taboos are a cost-effective way to manage NTFP harvesting, recent studies cite external influences like Christianity and formal education as factors weakening these taboos (Tang & Gavin, 2016; Sinthumule, 2024a, b), threatening resource governance, especially on communal lands. Similarly, although it is illegal to cut down marula trees in southern Africa (Zimbabwe, South Africa, Namibia, and Malawi), individuals often ignore these customary rules. For example, branches and whole trees are cut for fuelwood, spoons, and maize stamps, which has led to a decline in marula woodlands, especially in communal areas (Ngorima, 2016). The study also found that harvesting dry wood is permitted by local communities; however, harvesting wet wood from communal land is prohibited. Those caught with wet fuelwood face fines, and their loads are confiscated. The fines vary depending on the load. According to the latest price list (published by the Mhinga Tribal Authority in July 2023) available at the time of the research, a person is fined R100 (US\$5.31) if caught carrying a load of wet wood on their head, and R500 (US\$26.56) if transporting it via a wheelbarrow. If caught with wet wood in a truck, the fine is R10,000 (US\$531.30), and the load is confiscated (Table 3). The money collected from fines is used for administrative purposes—including purchasing stationery and printing toner—at the tribal office.

Table 3 Most recent price list (published by the Mhinga tribal authority in July 2023) for offenders available at the time of the research

Activity	Fine	Fine
Wet wood carried on the head	R100	US\$ 5.31
Wet wood carried on a wheelbarrow	R500	US\$ 26.56
Wet wood carried in a car (boot space)	R1 500	US\$ 79.69
Wet wood carried in a bakkie	R5 000	US\$ 265.65
Wet wood carried by a truck	R10 000	US\$ 531.30

Therefore, the collected funds are reinvested to provide services to community members who need assistance from the tribal office.

This means that permission must be obtained from the tribal authority before cutting fruit and non-fruit trees that are considered important by the community. Although TEK (rules, regulations, and taboos) plays an important role in managing the collection of mopane worms and marula fruits, helping to protect these species, other activities also directly threaten the survival of mopane and marula woodland species. For example, the two villages are expanding rapidly, requiring more land for residential and agricultural use. As noted, livestock is also a vital source of livelihoods in both Matiyane and Muyexe. Consequently, land conversions such as allocating residential stands, agricultural plots, and pressures from fire, browsing, and trampling by domestic livestock on small trees and new growth may negatively impact the mopane and marula woodlands in the study areas. Sekonya et al. (2020) and Dube and Chitakira (2024) have reported that these practices have led to a decline in mopane woodland abundance, especially on communal land. Although respondents did not explicitly mention the decline of mopane and marula woodlands in Matiyane and Muyexe due to these activities, there is a potential risk of decline based on current human activities related to development and land use. This could have long-term effects on the availability of mopane worms and marula fruits in both communities.

Methods for Harvesting NTFPs

The Muyexe respondents explained that they harvest mopane worms by hand from the trees and the ground. Picking mopane worms manually from the ground, tree trunks, and branches is common in southern Africa (Manditsera et al., 2022). Respondents said they do not climb the trees; instead, they wait for the worms to crawl down the trunk or onto the ground. Usually, both men and women harvest mopane worms, but women typically do this work, as seen in Zimbabwe (Dube & Chitakira, 2024) and Botswana (Mogomotsi et al., 2018).

They do not cut down the trees or branches of mopane trees to make harvesting easier. As one respondent clearly stated:

It is not permitted to cut branches from trees. It is also unnecessary to do so since there are more than enough mopane worms on the leaves or stems of mopane shrubs. I have been harvesting mopane worms for over 20 years and have never seen anyone climb or cut branches from mopane trees. (#Interview, community member, 2023)

Therefore, cutting mopane trees or branches is strictly prohibited, and offenders may be driven away from the area and could also face a fine. As clarified by a member of the tribal council:

You can harvest anywhere within the communal land, but cutting branches or mopane trees is strictly prohibited. Our bylaws do not permit harvesting that is not sustainable. If they destroy the trees, where will they find food tomorrow? We understand that harvesting mopane worms plays a vital role in the lives and livelihoods of our people, but it must be done responsibly. (#Interview, tribal council member, 2023)

Thus, traditional by-laws and community attitudes toward mopane woodlands in Muyexe have played a significant role in protecting mopane trees. As a result, the village has abundant mopane woodlands. These findings contrast with those of Thomas (2013), who reported that in Namibia, commercial harvesters of mopane worms are accused of destructive practices such as climbing trees, cutting off branches, and felling entire trees during harvest. Similarly, in Gwanda District in southwestern Zimbabwe, harvesters were reported to damage vegetation during the harvesting period, leading to decreased mopane woodland densities (Dube & Chitakira, 2024). In the case of Matiyane, marula fruits are collected and eaten—either fresh or as juice, wine, or beer—by a large portion of the community. In principle, both men and women can harvest marula fruits; however, I found that it is usually women who collect them, as in Zimbabwe (Mguni et al., 2023), Namibia (Wynberg et al., 2002), and Swaziland (Murye & Pelsner, 2018). When respondents were asked how they harvest marula fruits, all said they typically harvest the fruits when they are ripe, after they have fallen from the tree. Although conventional science discourages harvesting fallen fruits, the case of marula fruits is different because pre-ripe fruits fall and ripen on the ground. According to Tapiwa (2019), the benefits of harvesting fruits from the ground include protecting the tree's growth, preventing diseases such as fungal infections, and avoiding damage to the tree. Additionally, this method makes the fruits accessible to people of all genders and ages. The traditional belief is that marula trees should harvest themselves without interference from people.

Respondents do not cut branches or climb trees to make harvesting marula fruits easier. As one woman revealed:

I do not even know how to climb a tree, and marula trees are tough to climb. Climbing trees to harvest marula is considered taboo. Those on the trees are not even ready for processing, so we gather the fruits that have fallen to the ground, as those are the ones ready for making beer. (#Interview, community member, 2024)

I found that wine or beer made from marula fruit is sold to generate income. Therefore, marula fruits serve as a livelihood source for communities in Matiyane. This is not unique to the study area; instead, literature shows that marula fruits are an important livelihood resource for the poor majority in southern Africa (Murye & Pelsner, 2018; Tapiwa, 2019).

Conclusion

I aimed to assess the role of TEK (rules, regulations, and taboos) in managing NTFP collection in Muyexe and Matiyane. I discovered that both communities have established customary systems for harvesting and managing NTFPs. Generally, common property is not owned by everyone but belongs to a clearly defined community, as seen in Muyexe and Matiyane, where access rules are based on community membership. This regulated common property system not only limits resource use, especially by outsiders, but also helps coordinate users, which is important for managing mopane worms and marula fruits. My study showed that local communities view marula and mopane woodlands as valuable resources that should be preserved for both current and future generations. Although this is not a conservation project per se, the respect and adherence to customary systems by local communities in Muyexe and Matiyane are positive signs for the long-term conservation of these species. These findings have important policy implications for conservationists, government officials working in the region, and policymakers. There is a need for adaptive local management systems that incorporate TEK from local communities in managing or governing NTFP collection to support long-term livelihoods and protect marula and mopane woodland communities. Management strategies for mopane and marula trees should be integrated into local and regional planning efforts. Efforts should also be made to communicate these strategies to relevant authorities to foster cooperation and raise awareness about the importance of these species for all user groups. To ensure the sustainable future of these woodland species, this study recommends that the government work with traditional leaders and communities to support and enforce existing traditional practices.

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Data Availability No datasets were generated or analysed during the current study.

Declarations

Ethical Approval and Consent To Participate This study received approval from the University of Johannesburg's Faculty of Science Ethics Committee (Ethics Reference Number: 2022-11-18/Sinthumule).

Human Ethics and Consent To Participate Declarations All participants in this study were assured that their data would remain anonymous and securely stored, and that their responses could not be linked back to them. As detailed in the manuscript, informed consent was obtained from all participants before their involvement.

Competing Interests The authors declare no competing interests.

Clinical Trial Number: N/A

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