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Are Mopani Worms a Mechanism for Mopane Tree (*Colophospermum mopane*) Conservation? An Evaluation of the Villages Around Giyani, Limpopo Province, South Africa

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Abstract

Background and Background Aims: *Colophospermum mopane* provides many benefits including mopani worms, firewood, timber for construction, and medicine. Despite *C. mopane* playing a significant role in the lives and livelihoods of communities within their range, they are destroyed because of unsustainable harvesting practices coupled with lack of management practices. Assessment of people's attitudes has become significant in studies dealing with the conservation of biodiversity. This study aims to assess the attitudes of local communities in and surrounding Giyani in Limpopo Province in South Africa towards the mopane tree and to determine if their attitudes relate to obedience to traditional rules and regulations.

Methods: Interview-administered questionnaires were used to systematically select 161 households in Muyexe village and 82 households in Nsavulani village. The questionnaire evaluated the biographical data of respondents, knowledge of mopane woodlands, importance of mopane trees and mopani worms, and their attitudes towards mopane tree conservation.

Results: The overwhelming majority of respondents in both villages had positive attitudes towards mopane trees for ethical reasons. Respondents were also positive that mopane trees should be protected for future generations. The positive attitude of most respondents relates to obedience to rules and regulations that do not allow cutting of wet *C. mopane*. Respondents only cut dead or dry mopane woodlands for fuelwood. Cutting or harvesting was done on a subsistence and sustainable basis.

Conclusion: The communities have shown that they are guardians of *C. mopane*. The study concluded that mopani worms serve a mechanism for *C. mopane* conservation in Muyexe and Nsavulani villages in South Africa.

Implications for conservation: The positive attitudes of local communities, and obedience to the customary rules and regulations is a positive sign not only for ethical reasons, but also for long-term mopane woodlands conservation. This approach encourages the long sustainability of mopane woodlands in the study area.

Keywords

Colophospermum mopane, conservation, communities, attitudes, mopane trees, mopani worms

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Introduction

Colophospermum mopane provides variety of social and economic benefits in areas where it is found. Literature suggests that mopane woodlands are found in communal, private and government land (Mapaure, 1994; Timberlake, 1996; Makhado et al., 2009; Sekonya et al., 2020). Of interest to this paper are the conservation of mopane woodlands in communal lands (outside protected area) where mopane trees host mopani worms, which are consumed for their nutritional value. The worm is the larval stage of the moth *Imbrasia belina* (Kwiri et al., 2020; Mnisi et al., 2022; Ruzengwe et al., 2023; Madimutsa et al., 2023) and is traded to generate income (Kozanayi and Frost, 2002; Thomas, 2013; Baiyegunhi and Oppong, 2016; Mogomotsi et al., 2018). Mopane trees also serve as a source of firewood to rural communities (Tietema et al., 1991; Timberlake, 1996; Musvoto et al., 2007; Makhado et al., 2009; Mapaure, 2011; Nikodemus et al., 2023). As Makhado et al. (2009) have noted, mopane wood is freely available and the most accessible source of energy, making them preferred by the majority of rural people who are poor and unemployed. *C. mopane* is also preferred because the wood burns slowly and produces good coal (Timberlake, 1996; Nikodemus et al., 2023). The tree also provides timber for construction of traditional structures (Timberlake, 1996; Mashabane et al., 2001; Nikodemus et al., 2023) such as huts, fencing and kraals (Madzibane and Potgieter, 1999; Mashabane et al., 2001). The timber of mopane woodlands is also used in mine props and as railway sleepers (Van Voorthuizen, 1976). A further interesting feature of mopane woodlands is that they serve as a source of medicine (Madzibane and Potgieter, 1999; Mashabane et al., 2001) and provide fodder for livestock such as cattle and goats (Wessels, 1999).

As Wessels (1999) has noted, extensive human utilisation of *C. mopane* and lack of management practices, particularly in communal land, has devastating effects on the environment. For instance, in Namibia, concern has been expressed about the dwindling mopane woodland due to overharvesting of firewood by households (Mapaure, 2011). Mopane woodlands are not only harvested for subsistence purposes (firewood in household) but also for commercial purposes as in the case of Mozambique (Foloma, 2004) and Botswana (Teketay et al., 2018). In Zambia, *C. mopane* is widely used to produce charcoal which is predominantly used in urban areas as a source of fuel (Wessels, 1999). As a result, many parts of southern Africa's mopane woodlands have been heavily destroyed or degraded because of unsustainable harvesting practices (Wessels, 1999). Thus, despite *C. mopane* playing a significant role in the lives and livelihoods of communities within their range, these woodlands are destroyed at an alarming rate and poorly managed. Literature suggests that a wealth of research has been done on *C. mopane* covering mainly the distribution (Mapaure, 1994; Timberlake et al.,

2010), characteristics (Van Voorthuizen, 1976) and utilisation of *C. mopane* (Mashabane et al., 2001; Mapaure, 2011; Makhado et al., 2009). A number of studies have also looked at mopani worms harvesting and utilisation (Gondo et al., 2010; Kozanayi and Frost, 2002; Thomas, 2013; Baiyegunhi and Oppong, 2016; Mogomotsi et al., 2018). Despite a lot of research done on *C. mopane*, little is known about the conservation attitudes of local communities towards this species. Assessment of people's attitudes has become significant in studies dealing with the conservation of biodiversity or natural resources (Badola et al., 2012; Kopnina et al., 2022; Megaze et al., 2017; Sinthumule & Mzamani, 2019). Studies focusing on the attitude of people are essential because they can disclose whether local communities are willing to cooperate or coexist with conservation objectives (Sinthumule, 2021), including as this applies to the protection of a particular species. Importantly, attitudes shown by people can help determine if conservation initiatives will be successful or not in the long run (Mir et al., 2015).

A wealth of definitions for "attitude" have been documented in the literature. However, in this study, we adopted what may be the most conventional contemporary definition of attitude developed by Eagly and Chaiken (1993) who defined an attitude as 'a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour' (p. 1). The extensively recognised evaluative dispositions, which range from positive to negative, influence individual activities and behaviour directly or indirectly (Fishbein and Ajzen, 1975; Eagly and Chaiken, 1998). Scholars who have written about attitude have treated attitude formation and expression as the results of a multicomponent process consisting of affective, cognitive and behavioural components also known as the tripartite model (Figure 1) (see Rosenberg and Hovland, 1960; Fishbein and Ajzen, 1975; Eagly and Chaiken, 1993; Breckler, 1984; Bakanaukas, et al., 2020). The affective component is associated with one's sensational feelings while emotions are related to an attitude object. The cognitive component includes perception, beliefs, thoughts and attributes associated with an attitude object, whereas the behavioural component indicates one's overt action or responses to the attitude object (Eagly and Chaiken, 1998; Haddock and Maio, 2008; Yang and Watson, 2022). This study contributes to the debate on attitudes of people and conservation of a natural resource on customary or communal land—outside protected areas. Thus, this is not a conservation initiative per se but people cooperating to protect resources for ethical reasons. This study aims to assess the attitudes of local communities towards *C. mopane* and determine if their attitudes relate to obedience to traditional rules and regulations. The analysis is not only critical for policy decisions but also important in providing an understanding of how the attitudes and current practices influence the sustainability of *C. mopane* species.

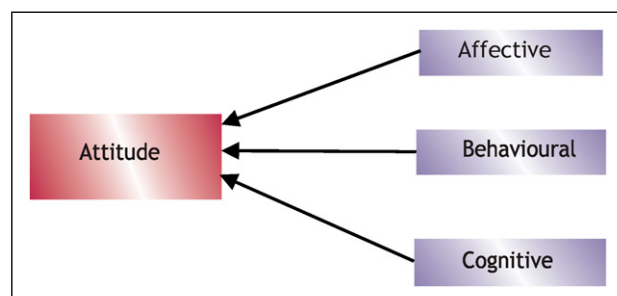


Figure 1. Multicomponent process of attitudes consisting of affective, cognitive and behavioural components also known as tripartite model.

Description of *Colophospermum mopane*

C. mopane (Kirk ex Benth.) Kirk ex J. Léonard, (commonly known as mopane) is a small to medium-sized deciduous, spineless tree belonging to the family Fabaceae or Leguminosae and monotypic (African) genus of the sub-family Caesalpinioideae (Mapaure, 1994; Wessels, 1999). *C. mopane* is a xeric species of the savanna woodland zone of south-central Africa and occurs within an altitudinal range of 300–1000 m above sea level (Timberlake, 1995, 1996; Van Voorthuizen, 1976). Although low scrub or dwarf mopane can only reach 1–2 m on shallow soil (Potgieter and Wessels, 1998), mopane trees usually grow up to 18 m high on deeper soils (Van Voorthuizen, 1976). Thus, the height of mopane woodlands can be taken as an indicator of soil depth (Mapaure, 1994). Mopane woodland generally occurs in monospecific stands (Timberlake 1995, 1996) with relatively few grasses, and the resulting woodland or shrubland has a low species diversity (Mapaure, 1994; Wessels, 1999). The woodland is widespread in the savanna biome of southern Africa where the soil is clay-rich (without excessive water-logging) and is generally shallow with alkaline and alluvial/colluvial soils (Cheikhyoussef et al., 2023). According to Van Voorthuizen (1976), *C. mopane* is found in areas receiving annual rainfall of between 400 and 1 000 mm.

However, the species can also be found in extremely arid areas such as in the northern Namib Desert region in Namibia, where rainfall is lower than 300 mm per annum (Viljoen, 1989). As noted by Timberlake (1995), areas where mopane woodlands occur tend to have a long dry season. The species is deciduous and grows slowly with an erect narrow crown (Wessels, 1999). The leaflets resemble butterfly wings and are characterised by seven to nine conspicuous veins radiating from the base (Villoen, 2014). The flowers are small (less than 1.3 cm across) pale green in colour and are borne in slender hanging tassels of 2–3 cm long (Van Voorthuizen, 1976). The literature suggests that there is variation in the area covered by mopane woodland. For instance, Timberlake et al. (2010) projected the area covered by mopane woodland at 380 000 km² whereas Mapaure (1994) estimated a much greater area at 550 500 km². *C. mopane* is found in southern

Angola, northern Namibia, north-eastern Botswana, southern and central Mozambique, southern parts of Malawi, and in the northern parts of South Africa (Van Voorthuizen, 1976; Mapaure, 1994; Timberlake, 1995; Illgner and Nel, 2000). It also occurs in the southern, western and northern parts of Zimbabwe and has arguably the largest area stretching into what is termed agricultural regions IV and V (Kwiri et al., 2020).

Methodology

Study Area

The study was conducted in Nsavulani (23° 31' 0.48" S, 30° 57' 17.28" E) and Muyexe (23° 11' 42.4" S, 30° 54' 57.49" E) villages under the jurisdiction of Greater Giyani Local Municipality (in turn under Mopani District Municipality) (Figure 2). The Mopani District Municipality is a Category C municipality located on the north-eastern side of Limpopo, a province of South Africa. The district is bordered by Kruger National Park and Mozambique to the east and Zimbabwe to the north. Mopani is one of five districts in Limpopo and has an area of 20,011.09 km².

The two villages, Nsavulani and Muyexe, are situated in the savanna biome and the vegetation is classified under Lowveld Rugged Mopane Veld (SVmp6) (Mucina and Rutherford, 2006). The Mopani District Municipality is named after the abundance of specimens of *C. mopane* (mopane tree) found in the area (Department of Cooperative Governance and Traditional Affairs [CoGTA], 2020). According to Fitchett et al. (2016), the district is categorised as a subtropical region with warm temperatures throughout the year and frost being a rare occurrence. The district receives an average rainfall of 500 mm per year, much of this falling between October and March. Seasonal drought occurs frequently (usually every 3–4 years) (Nembilwi et al., 2021).

Communal Land Governance and Management. Both Muyexe and Nsavulani villages are communal land falling under Chief Muyexe and Chief Nsavulani respectively. Although communal lands are state land, these villages are administered by Chief Muyexe and Chief Nsavulani who act as custodian of the land. Thus, local chiefs are responsible for the allocation of land for various purposes, administration, and management of natural resources. Both Muyexe and Nsavulani communal lands have similar customary rules and regulations formed in regulating or governing *C. mopane*. For instance, only local communities (residence) of Muyexe and Nsavulani villages are allowed to harvest mopane worms whereas outsiders are required to buy a daily permit for R100 to harvest mopane worms during mopane worm season. Whilst local communities are allowed to harvest dry fuelwood from mopane woodlands only for household consumption, outsiders are not allowed this benefit even if they are prepared to pay money. These customary rules and

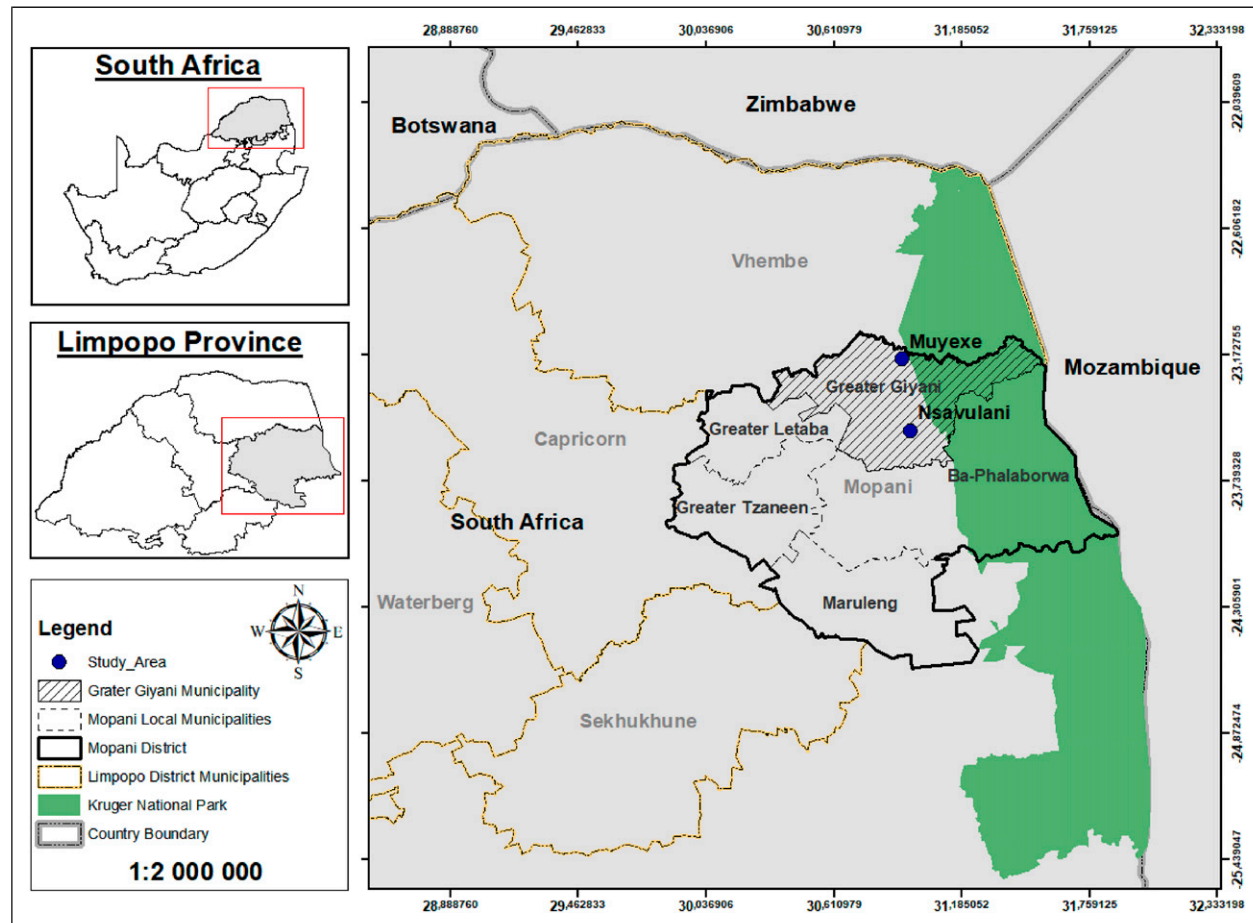


Figure 2. Location of Muyexe and Nsavulani villages under the Mopane District Municipality in Limpopo Province of South Africa.

regulations were formed by the chief and the tribal councils of the two villages. The tribal council is the highest decision-making committee appointed by the chief to serve in the cabinet. The roles of traditional council members include administering the affairs of the traditional community according to customs and tradition, assisting, supporting, and guiding traditional leaders in the performance of their functions. In addition, they are involved in developing policy and legislation, enforcing the rules and regulations, and promoting traditional practice for sustainable natural resource management.

The traditional council members have the authority to stop and impose penalties on outsiders. Penalties can be in the form of a fine, confiscation of harvested resources or both. In extreme cases, you can also be arrested and only be released after paying a fine. The main threat of outsiders to the village communal land includes harvesting of natural resources (wood, mopane worms) without permission from the chief or tribal council. This is because harvesting or collection of resources can be done in an unsustainable way such as cutting wet fuelwood for commercial purposes, or cutting of trees or branches of trees when harvesting mopane worms which is not allowed. Both Muyexe and Nsavulani villages borders

Kruger National Park and have an entrance gate and a security guard and in addition, they are both surrounded by a fence aiming to control the spread of diseases from wildlife from the Kruger National Park to domestic animals in communal lands. This makes enforcing rules and regulations easy, especially regarding people from outside who may want to access *C. Mopane* or any other resources within the two villages.

Data Collection

Permission to conduct this research was obtained from the Faculty of Science Ethics Committee of University of Johannesburg (Ethics Reference Number: 2022-11-18/Ndidzulafhi). The local authorities in the villages of Muyexe and Nsavulani also gave authorization for this research to be undertaken in their villages. In addition, consent was requested from the respondents before they were interviewed. At the start of each interview, participants were informed about the scope and purpose of this research. It was also made clear that participation in this research was voluntary and their identities would not be disclosed. They were further informed that they would not be remunerated and that they could

withdraw their participation at any time should they no longer want to take part in the research. Data was obtained from local communities in Muyexe and Nsavulani via interview-administered questionnaires in June and July 2023. The questionnaire combined closed- and open-ended questions with the latter included to allow informants to express their beliefs in their own words regarding the topic under investigation (White et al., 2005).

The questionnaire covered the biographical data of respondents, knowledge of mopane woodlands, the importance of mopane trees, and their attitudes towards mopane tree conservation. The questionnaire was translated from English into the local language, Tsonga, by an expert in English and African languages. The average duration of respondent interviews was approximately 30 minutes; the interviews were conducted verbally in Tsonga by three research assistants who were native speakers of the language and who had also received two days of training on carrying out the interviews. Following Budlender (2003), the questionnaire targeted the household head; in the event the household head was absent, any adult member (18 years and older) who had lived in the household for at least one year was interviewed. The questionnaire was administered at a convenient time for the respective respondents; all the interviews took place during daylight hours (between 9h00 and 17h00) excepting on a Sunday. In line with Hilton (2017), the questionnaire was pretested on three research assistants and 20 respondents in Thomo village not only to check inconsistency and ambiguity of questions, but also to test the sampling technique feasibility. This allowed definitions to be refined and gave the opportunity to identify and correct inconsistencies and potential for misunderstandings.

Sampling Approach

A probabilistic systematic random sampling method was used for the selection of households in Muyexe and Nsavulani villages. In a systematic random sampling procedure, the first subject is selected at random, whereas subsequent subjects are chosen systematically (Rahman et al., 2022). The main advantage of using systematic random sampling includes reducing the potential for bias in the selection of respondents, reduces the risk of favouritism, and creates an even distribution of members to form samples. This means the data collected using this approach has a better chance of being an authentic representation of the entire population (Bernard, 2017). The sample size was determined using well known Taro Yamane's formula as indicated below.

$$n = N/1 + N(e)^2$$

Where, n represents the sample size. n is the sample size N represents the total population. e represents the level of significance. 1 represents a constant value.

This formula was used because it is simple, timesaving, and cost effective. Importantly, it was used because households in the study area were homogenous, and the exact number of households were known (Yamane, 1967). Distribution of selected sampling households in Muyexe and Nsavulani appears in Table 1. Although there are a total of 826 households in Muyexe village, only 270 households were distributed along the *C. Mopane* belt on the eastern side of the village. As a result, a sample of 161 households was selected at a 95% confidence level and 5% margin of error. Similarly, in Nsavulani village with 548 households, only 102 households are found along the *C. Mopane* belt. As a result, a sample of 82 households was selected at a 95% confidence level and 5% margin of error. Whilst the total households were obtained from census statistics, the total households bordering the mopane belt was obtained from the tribal authorities in Muyexe and Nsavulani villages. As Walliman (2017) has noted, systematic random sampling requires the selection of samples based on special intervals. Thus, questionnaires were administered in five consecutive households after which we jumped the sixth household. However, in cases where the household head or person above the age of 18 was not present, another household was selected. This was done until the required households were obtained in both villages. Although Muyexe and Nsavulani are villages, they have properly designed streets that made it easy to move from one household to another and determine sampling interval.

Data Analysis

Quantitative data was analysed using Statistical Package for Social Sciences (SPSS) version 25 for Windows (IBM SPSS Inc, Chicago, IL, USA). The attitudes of people towards *C. mopane* were measured by responses to 11 related questions (Table 2). Each question was measured using a three-point Likert-type scale i.e., 'positive', 'neutral', and 'negative'. An open-ended question was also included in all the questions, enabling respondents to provide explanations as to why they made their choice. Cross tabulations involving chi-square (χ^2) tests were used to establish the relationships between selected socio-demographic variables and attitudes of people towards *C. mopane* conservation. Differences were considered to be significant at $P \leq 0.05$. After finding out a significant relationship in the original analysis, a post hoc test, with Bonferroni correction for multiple comparisons, was conducted to determine which group(s) are not independent (i.e. which value in the contingency table with a negative number that is smaller than the critical value or a positive number that is greater than the critical value is driving the statistical significance).

All the open-ended questions were analysed using thematic content analysis. According to Braun and Clarke (2006), thematic content analysis is a qualitative analytic method of "identifying, analysing and reporting patterns

Table 1. Distribution of selected sampling households in Muyexe and Nsavulani.

Village	Total Households	Households along <i>C. mopane</i>	Sampled household
Muyexe	826	270	161
Nsavulani	548	102	82

Table 2. Attitudes of local people towards conservation of mopane trees in Muyexe and Nsavulani villages.

Conservation attitude question	Muyexe %			Nsavulani %		
	+	0	-	+	0	-
Do you agree/disagree that mopani worms exist for the betterment of people in this village?	100	00	00	100	00	00
Are you satisfied that your village is located near mopani woodlands where you can harvest mopani worms?	100	00	00	100	00	00
Have your actions and behaviour resulted in the protection of mopani woodlands in this village?	61	30	09	71	13	16
Do you think harvesting of mopane trees for fuelwood and poles has led to the destruction of mopani woodlands?	11	00	89	10	00	90
Do you agree/disagree that mopane trees should be protected wherever they are found?	100	00	00	100	00	00
Do you agree/disagree with the traditional rules and regulations aiming to protect mopane trees in this area?	94	00	06	83	00	17
I would vote for a counsellor who promised to protect mopane trees in this village.	80	00	20	83	00	17
Are you willing to donate money that can be used to protect mopane trees?	77	00	23	72	00	28
Penalties should be imposed on people who cause mopane trees destruction.	91	00	09	89	00	11
People in this area have positive attitudes towards mopane trees.	100	00	00	100	00	00
Overall, do you like or dislike the mopane trees?	100	00	00	100	00	00

(themes) within data". To gain an understanding of the data, the transcription notes were read critically, noting down initial ideas. The interview extracts were tabulated on Microsoft Excel and key phrases from the data were highlighted in different colours according to categories. In line with Elliott (2018), data were grouped by codes, giving us a more complete overview of key points and common meanings that have been echoed in all our data. From the code, various patterns (common meanings) were identified and in the end the data were organized data into potential themes, by gathering all data relevant to each theme. In the end, two main themes were identified, and this included knowledge of mopane woodlands and the importance of mopane trees (further explained in the results section).

Results

Profile of Respondents

For the questionnaire sample in Muyexe village, a total of 69% of the sample were female respondents and 31% were male respondents whereas in Nsavulani village, a total of 59% of the sample were female respondents and 41% were male respondents. In both villages, the study was performed on weekdays when men were likely to be at work and as a result, women (who in the villages studied are largely focused on domestic chore) became the primary respondents. Informants significantly varied in age. In Muyexe village, 15% were in the 18–30 age category, 45% were in the 31–50-year-old age range, 22% were 51–60 years of age, and the

remaining 19% were above 61 years of age. In contrast, Nsavulani village, 20% were in the 18–30 age category, 41% were in the 31–50 age range, 17% were between 51 and 60 years of age, and the remaining 22% were above 61 years of age. In both villages, the unemployment rate was high, with only 37% of the population employed in Muyexe village compared to only 9% in Nsavulani village. These values may be an underestimate of the number of people employed because those working were likely to have been at work during the administration of the questionnaire. Those employed in both villages were beneficiaries of the Expanded Public Works Programme, a government programme focusing on skills development and providing work opportunities to reduce levels of poverty and unemployment.

Respondents had significantly varied sources of income in Muyexe village, with 55% relying on part-time jobs, 20% on pensions and 19% on child grants; only 6% of those in the employable age range had formal employment in Muyexe. Similarly, in Nsavulani village, 40% relied on part-time jobs, 30% on pensions, 25% on child grants and just 5% of the eligible population had formal employment. In terms of marital status, 44% (n = 71) were married, 35% (n = 57) were single and the remaining 20% (n = 33) had been widowed in Muyexe village, whereas in Nsavulani village, the majority (52%; n = 43) were married, 35% (n = 29) were single and the remaining 13% (n = 10) had been widowed. Just over half the people in Muyexe village and Nsavulani village had secondary education (52%; n = 84; and 51%; n = 42; respectively). Most of the respondents in Nsavulani (70%) and Muyexe (82%) villages had stayed in

the area for more than 10 years. Furthermore, most households sampled had a family size of 0–5 73% in Muyexe village, as compared to 72% in Nsavulani village.

Knowledge and Significance of *C. mopane*

Knowledge questions regarding *C. mopane* were designed to understand whether respondents knew mopane woodlands and, if so, to indicate the importance of this species in their lives and livelihoods. All respondents indicated that they knew *C. mopane* and it was further indicated that this species was the most abundant plant species in both villages. Interview extracts showing that respondents are familiar with *C. mopane* included: ‘We sit under a mopane tree’; ‘The tallest tree you see over there is a mopane tree’; ‘The trees you see on the left- and right-hand-side of the road when entering this village are mopane trees’; ‘The dominant trees you see on the eastern side of this village are mopane trees’, and ‘Last year I harvested five litres of mopani worms from those two mopane trees’. This information shows that communities in both villages were aware of the *C. mopane* tree. Respondents were asked to list the importance or benefits of *C. mopane* (Figure 3). All respondents in both villages indicated that *C. mopane* woodlands are important as they provide mopani worms which are an important source of nutrition. Most respondents in Muyexe village (89%; n = 143) and Nsavulani village (91%; n = 75) indicated that *C. mopane* is an important source of wood. Some of the respondents also indicated that *C. mopane* is an important source of medicine and plays an important role in protecting local communities from wind (Figure 3). Common medicinal uses of *C. mopane* that were mentioned included treating stomach aches, wounds, diarrhoea, toothache and menstrual pain.

Attitudes Towards *Colophospermum mopane*

Views of community members on *C. mopane* were mixed, with opinions ranging from positive to negative (Table 2). We found a unanimous positive perception that mopani worms exist for the betterment of local communities, satisfaction about living close to mopani woodlands, and recognition of the importance of *C. mopane*. Some respondents indicated that their love for mopane trees made them guard the species against heavy destruction (by portable chainsaws), particularly by outsiders (that is people from other villages) who want to sell the wood on a commercial basis. In addition, all respondents in both Muyexe and Nsavulani were of the opinion that mopane trees should be protected wherever they are found because they not only provide food but are also an important source of wood and medicine.

The study also evaluated whether the respondent’s conservation attitude towards *C. mopane* vary significantly within the categories of selected socio-economic variables including gender, education and occupation. Responses on the awareness of customary rules and regulations were not statistically significant between males and females in Muyexe ($\chi^2 = 0.86, P = 0.5205$) and Nsavulani ($\chi^2 = 0.86, P = 0.3526$) villages. Despite this, the attitudes were largely positive between males (94%) and female (96%) in Muyexe and between males (79%) and female (85%) in Nsavulani village. Importantly, respondents were also obedient to the customary rules and regulations in both Muyexe and Nsavulani villages. It was stated that the traditional rules and regulations should not stop local communities from harvesting wood but should stop those who come from outside who want to harvest for commercial purposes. We compared the awareness of rules and regulations by education level, which included four levels: no education, with primary, secondary, and tertiary education. The responses were significantly different in both

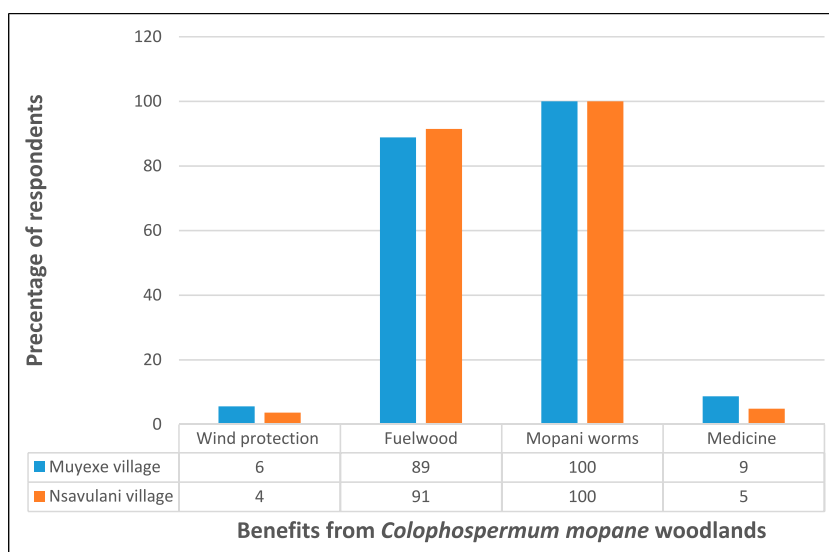


Figure 3. Benefits of *Colophospermum mopane* woodlands in Muyexe and Nsavulani villages.

Muyexe ($\chi^2 = 27.46$, $P = 4.72e-06$) and Nsavulani ($\chi^2 = 29.90$, $P = 1.451e-06$) villages. With the post hoc test, we find that the people with no education showed a significantly higher awareness of rules and regulations in Muyexe village, whereas people with secondary education showed higher awareness in Nsavulani village. We also looked at differences in awareness of rules and regulations by occupation, including people who are unemployed, self-employed, and employed. The variables were significantly not independent in both Muyexe ($\chi^2 = 11.17$, $P = 0.003759$) and Nsavulani ($\chi^2 = 22.85$, $P = 1.091e-05$) villages. Bonferroni post-hoc test showed that unemployed people were more aware of rules and regulations in Muyexe village, whereas the employed population showed significantly higher awareness than unemployed residents in Nsavulani village.

Responses on gender and whether their actions and behavior has resulted in the protection of mopani woodlands was not statistically significant in both Muyexe ($\chi^2 = 1.04$, $p = 1$) and Nsavulani villages ($\chi^2 = 0.33$, $p = 0.5641$). However, the attitudes of males (83%) and female (83%) in Muyexe and the attitudes of males (85%) and female (81%) in Nsavulani village were largely positive. This is because they only cut dead or dry mopane woodlands for fuelwood and cutting was done on a subsistence and sustainable basis. In addition, they were against people from outside their villages wanting to harvest *C. mopane* for commercial purposes. We compared the level of education and whether respondents' actions and behavior has resulted in the protection of mopani woodlands and found statistically significant relationship in both Muyexe ($\chi^2 = 41.42$, $p = 2.394e-07$) and Nsavulani villages ($\chi^2 = 43.87$, $p = 1.609e-09$). We found that people with tertiary education level in both Muyexe and Nsavulani village were less likely to report actions and behavior for mopani protection, as compared to other groups. We also looked at difference in employment status and whether respondents' actions and behavior has resulted in the protection of mopani woodlands and responses significantly differed in both Muyexe ($\chi^2 = 28.38$, $p = 1.045e-05$) and Nsavulani villages ($\chi^2 = 32.21$, $p = 1.014e-07$). We found that self-employed residents of Nsavulani were less likely to report actions and behavior for mopani protection than unemployed or employed respondents. In Muyexe, self-employed residents report more of these actions and behavior than unemployed respondents. When respondents were asked if harvesting of mopane trees for fuelwood and poles has led to the destruction of mopane woodlands in the area, by far the majority of respondents (89% and 90% said 'no' in Muyexe and Nsavulani, respectively), and the remainder said they were unsure.

Responses on gender and willingness to donate money that can be used to protect mopane woodlands was not statistically significant in Muyexe ($\chi^2 = 1.76$, $P = 0.1846$) and Nsavulani ($\chi^2 = 7.21$, $P = 0.007236$) villages. However, the attitudes of males (76%) and female (85%) in Muyexe and the attitudes of males (82%) and female (65%) in Nsavulani

village were largely positive. We looked at the relationship between education level and the willingness to donate money that can be used to protect mopane woodlands and found only a statistically significant relationship in Nsavulani ($\chi^2 = 23.87$, $P = 2.65e-05$). Residents with secondary education level were significantly more willing to donate in this village compared to other groups. We examined the difference in willingness to donate money for mopane protection by employment status and found a statistically significant in Muyexe ($\chi^2 = 7.108$, $P = 0.0286$) and in Nsavulani ($\chi^2 = 25.653$, $P = 2.688e-06$) villages. Self-employed residents reported significantly higher willingness to donate in both Muyexe and Nsavulani village as compared to the other two groups. Of the 125 respondents in Muyexe village who were willing to give a donation, the majority of the respondents 74% ($n = 93$) said that they could donate R10 (\$0.53). Similarly, of the 59 respondents in Nsavulani village who were willing to donate, the majority (85%; $n = 50$) were prepared to donate R10 (\$0.53) (Figure 4). Most respondents indicated that R10 (\$0.53) was the maximum they could donate because considering that they are poor, unemployed, and money is in short supply.

A total of 80% of the respondents in Muyexe and an even higher 83% in Nsavulani were also willing to go the extra mile of voting for a politician who promised to protect mopane trees. Those who did not support this assertion were of the view that politicians were the most corrupt officials and who could not be supported by sober-minded people. Other dominant positive responses related to the need to impose penalties on people who cause mopane woodland destruction 91% in Muyexe, compared with 89% in Nsavulani village.

Discussion

This study has shown that *C. mopane* and the rest of natural resources that are found in both Muyexe and Nsavulani villages are common property resources. Heltberg (2002: 193) defined common property to refer to "resources under communal ownership where access rules are defined with respect to community membership". Such resources are owned by an identified group of people who are invested with the legal ability to exclude non-owners (Ciriacy-Wantrup & Bishop, 1975). Thus, common property is not 'everybody's property,' but the property of those who are members of a group or community of co-equal owners (Ostrom, 2000). In the case of Muyexe and Nsavulani villages, the local chiefs act as custodians of the two communal lands. The chiefs together with their tribal councils have created rules and regulations that govern the use of resources within their area of jurisdiction. The traditional rules and regulations are not part of an elected political system, but rather they are local management systems controlled by local traditional authorities. This is what Heltberg (2001, 2002) called 'regulated common property' where both access and conservation rules are in place. Unlike open access or unregulated common

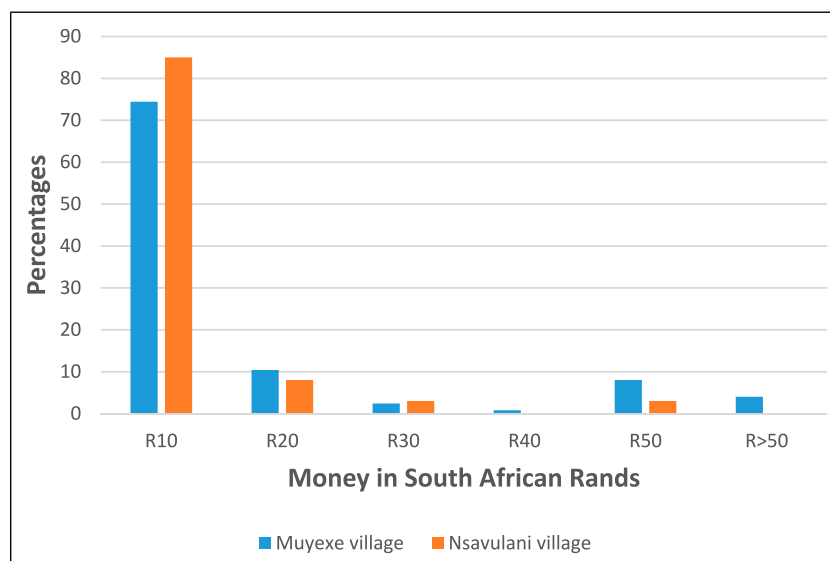


Figure 4. The amount of money respondents was willing to donate for the protection of mopane trees in Muyexe and Nsavulani villages.

property that can lead to Garrett Hardin's 'the tragedy of the commons' (Hardin, 1968), in regulated common property, members of a clearly defined group (in this case, Muyexe and Nsavulani villages) can exclude others. For instance, people who do not reside in Muyexe and Nsavulani villages are excluded from collecting mopane wood and mopane worms. They can only be allowed to harvest mopane worms if they have paid a levy, and they have a written permit from the tribal authority. This is consistent with Gondo et al. (2010) who reported that some rural district councils in Zimbabwe have already imposed a levy on traders coming from outside the district to harvest mopane worms.

This study has also revealed that in the study area, rules and regulations are enforced by the tribal council members. The traditional council is also responsible for monitoring any violations of the rules and regulations within the villages. This study found that offenders of existing rules and regulations are required to pay a fine, confiscation of harvested resources or both. Importantly, community members in both villages were found respectful, obedient, and have positive attitudes towards traditional rules and regulations because they are part of their culture or everyday life. This has been effective in managing *C. Mopane* woodlands and harvesting mopane worms. This is not unique to the study area; other studies in communal areas of Africa (Boafo et al., 2016; Mavhura & Mushure, 2019; Ntoko & Schmidt, 2021; Sinthumule & Mashau, 2020) and Asia (Gao et al., 2013; Negi et al., 2018) have also found that enforcing customary rules and regulations coupled with cooperation by local people have played a significant role in natural resources conservation outside protected areas. Whilst there are success stories about customary rules and regulations, there are also cases where lack of enforcement of existing customary rules and regulations did not achieve the desired outcome. For

instance, rules for mopane worm harvesting in Mwenezi resettlement areas and Chikombedzi communal area in Zimbabwe were found to be weak because they were not enforced (Mufandaedza et al., 2015). Similarly, in Namibia, commercial harvesters of mopane worms are accused of destructive practices such as climbing trees, cutting off branches and cutting down whole trees when harvesting mopane worms because of poor enforcement of rules and monitoring systems (Thomas, 2013). These practices contribute to unsustainable utilization of natural resources (Mufandaedza et al., 2015). Thus, whilst having rules and regulations outside protected areas (in communal lands) is important for sustainable utilization of natural resources, it is not a sufficient solution particularly if the rules are not enforced. Similarly, if there are no monitoring mechanisms, rules and regulations cannot be effective in managing or governing natural resources in communal lands.

The study also found that since respondents are respectful and obedient to customary rules and regulations, they were of the perception that traditional authorities should impose harsh penalties on people who destroy mopane trees. Thus, respondents feel bad when they see people (particularly outsiders or people from other villages) destroying mopane woodlands. It is for this reason that local communities report anyone found cutting *C. Mopane* species on a commercial basis to the traditional authorities. In the present study, the commercial harvesting of mopane trees evoked negative attitudes, particularly when this activity was attributed to people from outside. In line with studies conducted by Rispoli & Hambler (1999), and Sinthumule (2021) motivation for the conservation of mopane trees tended to be ethical (value *C. mopane* for many purposes including cultural reasons), with most interviewees expressing their willingness to go the extra mile by contributing money and electing a local politician

who promises to protect mopane woodlands. Previous studies have also shown that people display significantly negative attitudes towards activities that pose danger to a resource they value (Anthony, 2007; Mogomotsi et al., 2020; Sinthumule & Mzamani, 2019; Wang et al., 2006).

While there is an emerging business of selling mopane wood, this study found that traditional rules and regulations do not permit local communities to harvest fuelwood on a commercial basis. The reliance on mopane trees for fuelwood and poles has not led to the destruction of mopani woodlands. As in the case of northern Namibia (Nikodemus et al., 2023), in the study area mopane trees are not being commercially harvested for fuelwood or poles; rather, the harvesting that is being carried out is being done on a subsistence basis. Despite the two villages having electricity, the majority of the respondents rely on mopani wood for household cooking because it is the cheapest source of energy, and it is believed that the food cooked using wood tastes better than the food cooked using electricity. The low level of commercial harvesting in the study area contrasts with the vicinity of the Okavango Research Institute (located in Maun in northern Botswana) where mopane woodland is harvested for commercial purposes (Teketay et al., 2018). This low-level harvesting contributes towards protection of *C. Mopane* outside protected areas. The protection of *C. Mopane* in communal lands supports bioregional planning or landscape regional model that encourages the protection of species wherever they are found (Brunckhorst, 2013). This study has shown that policymakers need to consider the increasing public support for mopane trees and their conservation in the landscape, to reflect the true values of society. The overwhelming positive attitudes towards mopane trees in both villages is a clear sign that communities in Muyexe and Nsavulani villages are custodians of their environment.

Implications for Conservation

This study has demonstrated that the residents of Muyexe and Nsavulani villages held a positive attitude towards the conservation or protection of mopane woodlands. This included their willingness to pay for the conservation of mopane trees, their determination to vote for an official who promises to protect mopane trees in their villages, and their preparedness to report anyone who destroys mopane woodlands to traditional authorities. Thus, local communities were shown to perceive mopane trees as a valuable resource that should be protected for present and future generations. They were also in support of the view that penalties should be imposed on people who destroy mopane trees. The respondents expressed happiness and obedience about customary rules and regulations in their communal lands that prevent destruction and commercial harvesting of mopane trees for wood and poles. This is not a conservation initiative per se but people organizing to create management of a resource in their communal lands for ethical reasons. The positive attitudes of local

residents and their obedience to the customary rules and regulations is a positive sign for long-term conservation of mopane woodlands. This study has shown that conservation can also be successful outside protected areas if local residents are willing to cooperate or respect traditional rules and regulations governing natural resources. Importantly, conservation can be successful if rules and regulations are enforced, and there are monitoring mechanisms in place. This approach to conservation is critical and is in line with bioregional planning that encourages protection of natural resources wherever they are found. This is a positive step towards protecting the remaining landscapes dominated by mopane trees.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Supplemental Material

Supplemental material for this article is available online.

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