

## Article

# Perceived Abundance and Cultural-Economic Use-Value of Tree Species in the Mopane Woodlands, Mopani District, South Africa

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## Abstract

Identifying the key products of mopane woodlands, the perceived abundance of species, and the associated use values have important implications for rural communities and the sustainable use of mopane woodlands. This study examined local perceptions of tree species abundance and their associated use-values across four communities in the Mopani District, South Africa. The semi-structured questionnaire and key informant interviews were used to collect the data. The data were analyzed using descriptive statistics, the Friedman test, the Smith Salience Index, Kendall's W, Pearson correlation, and the Fidelity test. There was a very strong level of agreement ( $W = 0.83$ ) among the communities regarding the perceived abundance of tree species, and this agreement was statistically significant ( $\chi^2 = 19.85, p < 0.05$ ). The *Colophospermum mopane*, *Sclerocarya birrea*, and *Combretum imberbe* are the most perceived abundant species in the study areas and have high value. The tree species with high use-value showed a positive correlation with the perceived abundance of tree species, conforming to the study's ecological apparency hypothesis. The more apparent species had more use value and perceived abundance.

**Keywords:** mopane woodland; perceived species abundance; use-value; conservation; forest resources

## 1. Introduction

The Mopane woodland is typically widely known as a woodland predominated by the native tree species of *Colophospermum mopane* (J. Kirk ex Benth). In southern Africa, the mopane vegetation type is widely distributed, covering large areas of land about 600,000 km<sup>2</sup> in countries including Angola, Botswana, Namibia, Malawi, Mozambique, South Africa, Zambia, and Zimbabwe [1–4]. In South Africa, mopane vegetation covers about 23,000 km<sup>2</sup> of the Limpopo and Mpumalanga provinces [5]. Mopane woodlands are the source of a wide range of subsistence products, including medicine, fuelwood, edible termites, sweeping and thatching grasses, edible mopane worms, edible locusts, poles, building sand, among others [6]. The unprecedented proliferation of poverty, unemployment, and environmental hardships in most developing countries (e.g., southern African countries) compels the rural population to shift from subsistence use of forest products to commercialization [5]. These changes have a detrimental effect on the ecological functionality and productivity of mopane vegetation, including biodiversity loss and depletion of forest products in terms of quality and quantity [5].



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Generally, overharvesting for commercial use disrupts the regeneration and delays the maturity of young trees [1]. In southern African countries, there is an increased demand for valuable forest products, which has subsequently accelerated the degradation of these resources [4]. There is thus a rapid decrease in mopane woodlands due to overharvesting for fuelwood and timber [4]. If the functionality and productivity of mopane woodlands are impaired, the capacity of the mopane woodlands to sustain the livelihoods of the rural communities will diminish over time. For example, Mopane woodlands produce edible mopane worms (*Imbrasia belina* moth caterpillars) that support and sustain the local economy, culture, and food security in rural communities of southern African countries [7]. Moreover, mopane worms generate revenue of approximately USD 39 million and USD 59 million annually in southern Africa [7]. The literature has well illustrated the association between forest resource use and human factors, such as economic status, level of education, culture, religious beliefs, age, and gender [5,8]. Human factors influence people's decision-making about where, how much, what, and how to harvest forest resources [9]. However, the perceived abundance of locally occurring tree species and their relationship to the use value of forest products in mopane woodlands has received limited research attention, particularly within the Mopani District in Limpopo, South Africa. This is a major concern affecting the regulations, control, and management of mopane woodlands. In addition, there is an inadequate management practice of forest resources in communal lands [4]. The lack of rules and regulations in mopane woodlands has led to unsustainable activities, including cutting branches for easy access to mopane worms and harvesting live trees for fuelwood, as well as frequent fires caused by unattended fires after mopane worm processing (e.g., cooking, boiling, or roasting) in the mopane woodlands [7]. This seriously threatens the rural livelihoods and resources of the mopane woodlands.

Ecological studies found that the composition of mopane vegetation species is commonly homogeneous and largely dominated by *C. mopane*, with few other species [10]. Though mopane vegetation is known to be dominated by *C. mopane*, there is variation in species composition in mopane vegetation due to the use of trees by local people [10]. According to Musvoto et al. [11], the mopane species is extensively utilized by local communities within mopane vegetation due to its multiple-use characteristics. Previous studies have shown a correlation between tree use and mopane vegetation composition, which exhibits changes over time [10]. In Namibia, shifts in species composition within mopane vegetation over time have led to changes in species use, with alternatives to mopane species such as *Hyphaene petersiana* increasingly being used for traditional medicine [10]. Several alternative tree species are utilized for various purposes, for example, *Combretum imberbe*, *Combretum hereroense*, *Terminalia sericea*, and *Dichrostachys cinerea* are commonly used for building materials; *Hyphaene petersiana* for firewood [10].

Mopane vegetation continues to face persistent pressure, with studies over the past decade reporting significant impacts from human settlements and subsistence harvesting, leading to notable changes and reductions in mopane cover [10]. Subsistence harvesting has altered the structural and functional integrity of mopane woodlands [12], while growing human demands pose a substantial threat to their sustainability [2]. Although *Colophospermum mopane* is currently classified as a species of 'Least Concern' on the IUCN Red List [3], its distribution is increasingly threatened by overexploitation. The species' slow growth and limited recovery capacity after disturbance further exacerbate this vulnerability [2,13]. Persistent overharvesting has the potential to severely compromise the distribution, productivity, and ecological functionality of mopane vegetation. In South Africa, rising demand and intensified harvesting have contributed to the growing overexploitation of mopane-derived products [5].

Perception of tree species abundance is guided by the patterns of resource use, long-term interactions between local people and their vegetation, and cultural values. The ecological knowledge of forest resources is transmitted through oral traditions and practices, resulting in a locally culturally embedded understanding of tree species uses, abundance, and distribution [14,15]. Therefore, Mopani District Vatsonga people's perception of abundance may influence harvesting, utilization, and management decisions at the local level. Once their perceptions of tree species are understood, it provides an opportunity to explore the feasibility of incorporating cultural practices into conservation planning [14]. The ecological apparency theory (EAT) predicts that plant species that are more apparent are more likely to be recognized and utilized by humans [16]. As predicted by EAT, apparent species are easier to remember, locate, and harvest, making them central to local ecological knowledge and perceptions of abundance. The Vatsonga people utilize trees and mopane woodlands for firewood, poles, tool-making, gathering wild fruits, fodder, traditional medicine, and ritual practices.

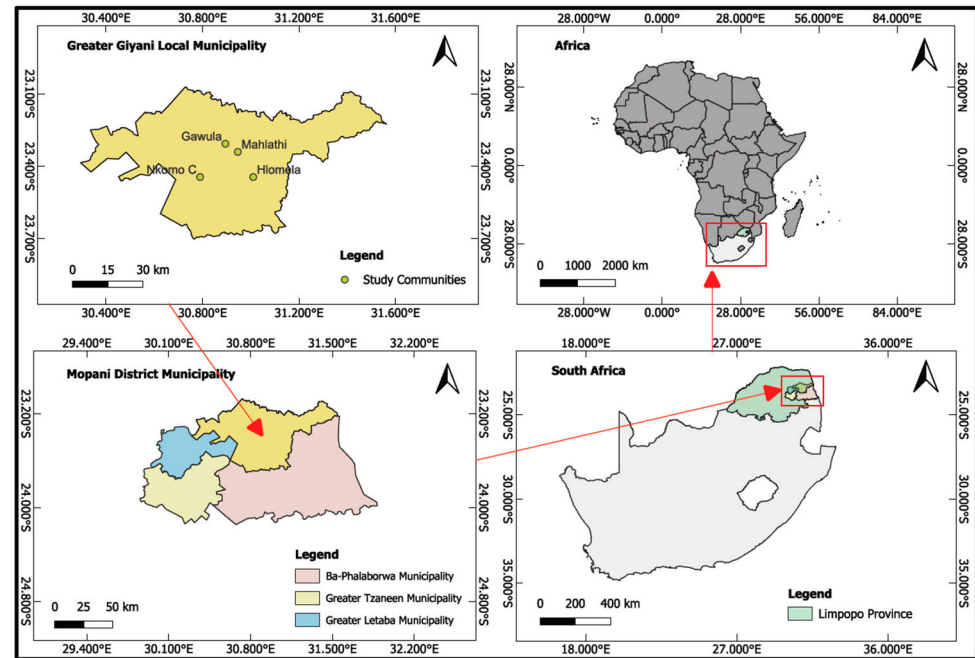
The multiple uses and abundance of *Colophospermum mopane* in mopane woodlands are well-documented. However, less is known about the perception of tree species abundance and the uses of alternative tree species in the mopane woodlands, particularly in the Mopani District, South Africa. To address this, the ecological apparency hypothesis offers a useful framework, positing that people tend to use species that are more visible and abundant in their environment [17]. This study hypothesized that the value of tree species is more closely linked to local perceptions of abundance, the higher the abundance of tree species, the higher the utilization. The present study, therefore, aims to evaluate how perceived abundance influences patterns of mopane woodlands resource harvesting and utilization. The following questions were addressed: (a) What are the woody and non-woody products harvested from the woodlands? (b) Which tree species are mostly used, and what are their uses? (c) Which tree species are perceived as abundant within the mopane woodlands?

## 2. Materials and Methods

### 2.1. Description of the Study Site

This study was conducted in January 2024 in four villages, Gawula (23°18'26" S, 30°53'40" E), Hlomela (23°26'42" S, 31°00'36" E), Nkomo C (23°26'42" S, 30°47'23" E), and Mahlathi (23°20'27" S, 30°56'46" E), which are in proximity to mopane woodlands in the Greater Giyani Municipality of Mopani District in Limpopo Province (Figure 1). The Mopani District Municipality (MDM) is situated in the north-eastern quadrant of Limpopo Province. It shares borders with Zimbabwe to the north, the Vhembe District Municipality to the south, Mpumalanga Province to the south, the Sekhukhune District to the southwest, Mozambique to the east, and the Capricorn and Vhembe District Municipalities to the west. The MDM has a population of over 1.3 million [18]. The district is dominated by rural communities (81%), and a notable percentage of the people are unemployed (39%) seeking work [19]. The Greater Giyani Municipality (GGM) is situated north of MDM and encompasses 4166.6 km<sup>2</sup> of land [16]. The population of GGM is 316,841, populated in 93 villages [19]. Greater Giyani Municipality has the highest number of unemployed people (47%) in the district [18]. The GGM residents rely on homesteads and small-scale farming activities, including maize, vegetables, tomatoes, and beef production [18]. Mopane worms and marula fruits are the other major sources of income for the rural communities of GGM. Due to the high level of poverty in GGM, the majority (49,908) of people depend on fuelwood, followed by electricity (20,009) and gas (9675) as sources of energy for cooking [18]. The GGM is dominated by Vatsonga people; the GGM forms part of the former homelands (Gazankulu). Forest resources are strongly managed and controlled through customary rules, traditionally protected by taboos and government policies [19].

The customary rules are linked to the community leadership, specifically the Chief (Hosi), and communal decision-making is conducted in a communal assembly (Huvo). The use of forest resources is controlled through access permits issued by the Tribal authority and Chief [20]. In Vatsonga culture, the elders are the custodians of ecological knowledge, which is passed down through oral traditions, including storytelling, proverbs, and praise poetry [15].



**Figure 1.** Map of Greater Giyani Local Municipality showing the study sites; the communities are highlighted with a green pin, Gawula, Mahlathi, NkomoC, and Hlomela.

## 2.2. Data Collection

The purposive sampling was used to select the study communities because they are located within mopane woodlands that are experiencing an unprecedented increase in unsustainable harvesting pressure [20]. The purposive approach sought to understand and address these challenges in the selected study communities [21]. The quantitative method was used to collect the data using a semi-structured questionnaire. The selected communities were Gawula, Hlomela, Nkomo-C, and Mahlathi. Ethical clearance to conduct the study was obtained from the University of Pretoria ethics committee (NAS101/2024). The number of households in each community was sourced from the community leaders (Chiefs) for sample size calculations and the design of the sampling. The sample size was calculated at 95% confidence intervals and 5% margin of error using the following Formula (1) [22]:

$$S = \frac{X^2 N p (1 - p)}{d^2 (N - 1) + X^2 p (1 - p)} \quad (1)$$

where  $S$  denotes sample size,  $X$  is the confidence interval,  $N$  is the population,  $d$  is the degree of accuracy (0.05), and  $p$  is the estimated level (0.5). The calculated sample sizes were 70 for Gawula, 65 for Hlomela, 75 for Mahlathi, and 46 for Nkomo C, totaling 256 households. A computerized random sampling program (random number generator) was used to randomly select households for interviews from the respondents. The questionnaires were administered through face-to-face interviews in all the randomly selected households. The perceived abundance of tree species was collected using the free-listing method [23]. The free-listing method was applied because people list the tree species they know and are

most familiar with in their woodlands [24]. A free listing of species tends to yield more results than a prelisted species [25].

### 2.3. Data Analysis

The data analysis of demographics, non-woody animal and plant products, and woody product utilization was conducted using the Statistical Package for the Social Sciences (SPSS) software version 23.0. The normal distribution of the data was tested using the Kolmogorov–Smirnov normality test [26]. The results showed a rejection ( $p < 0.05$ ) of the null hypothesis of normal distribution. Therefore, the non-parametric analysis was applied. Demographic data were analyzed using the crosstabulation in percentiles. The Friedman test was used to determine the most commonly utilized mopane woodland products and to test for differences in utilization among the woodland products. The results were considered significant at  $p < 0.05$ , and the means were ranked in descending order. The Fidelity Level (FL) technique was used to assess the tree species use value [27]. The following FL Formula (2) was used:

$$FL(\%) = \left( \frac{\sum l_p}{l_u} \right) \times 100 \quad (2)$$

where  $FL$  denotes fidelity level or use-value,  $l_p$  denotes the citation/mention of the tree species for use and abundance, and  $l_u$  denotes the total number of respondents per community. The total use value was the summation of all use values of the communities for each tree species. The Smith Salience Index was used to measure the perceived abundance of tree species in the mopane woodlands. The Smith salience index measures the frequency of mentioned species and ranks the species based on the position the species was mentioned [23]. The Smith salience index Formula (3):

$$S_i = \frac{1}{N} \sum_{j=1}^{N_i} \left( \frac{L_j - R_{ij} + 1}{L_j} \right) \quad (3)$$

where  $N$  denotes the number of respondents,  $N_i$  denotes the number of respondents who listed the species  $i$ ,  $L_j$  denotes the length (number of species) of respondent  $j$ 's list, and  $R_{ij}$  denotes the rank position of species  $i$  in respondent  $j$ 's list. Smith's salience index close to 1 means very salient (species frequently mentioned early) and close to 0 means low salience (species rarely mentioned or mentioned late). The ANTHROPAC 4.983 software was used to analyze Smith's salience index using the free-listing data [23]. Only the tree species with a Smith index closer to 0.1 were recorded in the top five (5). The Kendall's Coefficient of Concordance ( $W$ ) was used to test the significance of the agreement of tree species Smith Salience ranks across the villages [28,29]. The  $W$  value closer to 1 indicates a stronger agreement, and the  $W$  value closer to 0 indicates a weaker agreement [30].

## 3. Results

### 3.1. Demographic Profile

Table 1 provides an overview of the study communities in the Mopane woodlands. Across all sites, the majority of respondents were middle-aged, ranging from 36 to 60 years old. Females predominated in each community, comprising 69% in Gawula, 61% in Mahlathi, 57% in Hlomela, and 61% in Nkomo-C. Social grants emerged as the primary source of household income in Mahlathi (27%), Hlomela (39%), and Nkomo-C (39%). Educational attainment was generally moderate, with most respondents having completed at least secondary education, 41% in Gawula, 46% in Mahlathi, 51% in Hlomela, and 61% in Nkomo-C.

**Table 1.** Demographics of community respondents.

Demographics		Gawula (n = 70)	Mahlathi (n = 74)	Hlomela (n = 65)	Nkomo C (n = 46)
Age	18–25	14.3	2.7	10.8	6.5
	26–35	30	21.6	23.1	37
	36–60	37.1	54.1	35.4	50
	≥61	18.6	21.6	30.8	6.5
Gender	Male	31.4	39.2	43.1	39.1
	Female	68.6	60.8	56.9	60.9
Source of Income	No income	21.4	21.6	35.4	19.6
	Employed	27.1	20.3	7.7	23.9
	Self-employed	20	23	6.2	17.4
	Pensioner	7.1	8.1	12.3	0
	Social grant	24.3	27	38.5	39.1
Education	No education	15.7	17.6	18.5	10.9
	Primary	12.9	18.9	15.4	19.6
	Secondary	41.4	45.9	50.8	60.9
	Tertiary	30	17.6	15.4	8.7

### 3.2. Mopane Woodland Non-Woody Plant and Animal, Woody Products Utilization

Table 2 reveals a statistically significant variation in the utilization of non-woody plant products among the study communities ( $p < 0.05$ ). Wild food was ranked the highest, with a mean of 0.69, followed by plant medicine (0.59), sweeping materials (0.53), wild fruits (0.45), and thatch grass (0.30). Table 3 shows a statistically significant difference in utilization of non-woody animal products across the study communities ( $p < 0.05$ ). Mopane worms were ranked the highest, with a mean of 0.84, followed by fish (0.73), bush meat (0.72), Birds (0.48), and honey (0.45). Table 4 shows a statistically significant difference in utilization of woody woodland products across the study communities ( $p < 0.05$ ). Fuel wood was ranked the highest, with a mean of 0.83, followed by poles (0.55), laths and droppers (0.48), wood carving (0.40), and timber (0.30). The charcoal production was the least mean-ranked (0.04).

**Table 2.** Mopane woodland non-woody plant products utilization.

All Communities (n = 256)		
Non-Woody Plant Products	Mean Rank	Statistics
Wild food (vegetables)	0.69 <sup>1</sup>	Chi-square = 513.444 Df = 9 $p = 0.000$
Fodder	0.18 <sup>8</sup>	
Medicinal plants	0.59 <sup>2</sup>	
Cosmetic (soap)	0.31 <sup>6</sup>	
Dye	0.02 <sup>10</sup>	
Herbs and spices	0.25 <sup>7</sup>	
Sweeping material	0.53 <sup>3</sup>	
Thatch grass	0.30 <sup>5</sup>	
Ornamental	0.16 <sup>9</sup>	
Wild fruits	0.45 <sup>4</sup>	

<sup>1–10</sup> Ranking ranging from highest (1) to (10).

**Table 3.** Mopane woodland non-woody animal products utilization.

All Communities (n = 256)		
Non-Woody Animal Products	Mean Rank	Statistics
Bush meat	0.72 <sup>3</sup>	Chi-Square = 594.476 Df = 9 p = 0.000
Honey	0.45 <sup>5</sup>	
Fish	0.73 <sup>2</sup>	
Hides and skins	0.26 <sup>8</sup>	
Medicine from animals	0.38 <sup>7</sup>	
Birds	0.48 <sup>4</sup>	
Termites	0.18 <sup>10</sup>	
Mopane worm	0.84 <sup>1</sup>	
Caterpillars (Locusts)	0.44 <sup>6</sup>	
Reptiles	0.21 <sup>9</sup>	

<sup>1-10</sup> Ranking ranging from highest (1) to (10).

**Table 4.** Mopane woodland woody forest products utilization.

All Communities (n = 256)		
Woody Forest Product	Rank	Statistics
Timber	0.30 <sup>5</sup>	Chi-square = 371.670 Df = 5 p = 0.000
Poles	0.55 <sup>2</sup>	
Fuelwood	0.83 <sup>1</sup>	
Wood carving and utensils	0.40 <sup>4</sup>	
Charcoal	0.04 <sup>6</sup>	
Laths and droppers	0.48 <sup>3</sup>	

<sup>1-6</sup> Ranking ranging from highest (1) to (6).

### 3.3. Perceptions of Tree Species Abundance and Use-Value Among Local Communities

Table 5 shows that there was a very strong level of agreement ( $W = 0.83$ ) among the communities on the perceived tree species abundance, and the agreement was statistically significant ( $\chi^2 = 19.85$ ,  $p < 0.05$ ). The *Colophospermum mopane* exhibited the highest Smith Salience Index perceived abundance across all the communities, Hlomela ( $S = 0.392$ ), Gawula ( $S = 0.343$ ), Mahlathi ( $S = 0.218$ ), and Nkomo C ( $S = 0.304$ ). Overall, *Colophospermum mopane* ( $S = 0.314$ ) was the highest perceived abundance, *Sclerocarya birrea* ( $S = 0.222$ ) and *Combretum imberbe* ( $S = 0.155$ ) ranked second and third respectively (Table 6). A total of 15 tree species was perceived to be abundant belonging to 9 families. The dominating families were fabaceae (five species) and combreteaceae (two species). Table 7 shows the tree species of high use value in mopane woodlands, *Colophospermum mopane* ( $UV = 67.8$ ), *Sclerocarya birrea* ( $UV = 36.4$ ), *Combretum imberbe* ( $UV = 28.9$ ), *Diospyros mespiliformis* ( $UV = 13$ ) and *Combretum molle* ( $UV = 11.2$ ). The tree species that have more multiple uses (e.g., fuelwood, medicine, constructions, fruits, fodder, etc.) in mopane woodlands include *Colophospermum mopane*, *Sclerocarya birrea*, *Diospyros mespiliformis*, *Vachellia karoo*, *Ficus sycomorus*, and *Dichrostachys cinerea*. There was a strong correlation between the tree species use-value and the perceived abundance in mopane woodland ( $R^2 = 0.971$ ,  $p < 0.05$ ). Figure 2 illustrates the correlation between the use value of tree species and their perceived abundance. The use value increases with the increasing perceived abundance of tree species.

**Table 5.** Top five (5) tree species Smith Saliency Index ranking.

Species	Communities Smith Saliency Index			
	Hlomela	Gawula	Mahlathi	Nkomo-C
<i>Colophospermum mopane</i>	0.392 <sup>1</sup>	0.343 <sup>1</sup>	0.218 <sup>1</sup>	0.304 <sup>1</sup>
<i>Sclerocarya birrea</i>	0.320 <sup>2</sup>	0.189 <sup>3</sup>	0.210 <sup>2</sup>	0.162 <sup>2</sup>
<i>Combretum molle</i>	0.140 <sup>3</sup>	0.072 <sup>5</sup>	-	0.142 <sup>4</sup>
<i>Combretum imberbe</i>	0.110 <sup>4</sup>	0.201 <sup>2</sup>	0.155 <sup>3</sup>	0.152 <sup>3</sup>
<i>Diospyros mespiliformis</i>	0.105 <sup>5</sup>	0.143 <sup>4</sup>	-	0.129 <sup>5</sup>
<i>Berchemia discolor</i>	-	-	0.107 <sup>4</sup>	-
<i>Cassia abbreviata</i>	-	-	0.098 <sup>5</sup>	-

<sup>1-5</sup> Saliency ranking from highest to lowest (1–5).

**Table 6.** Overall Smith Saliency Index ranking of tree species.

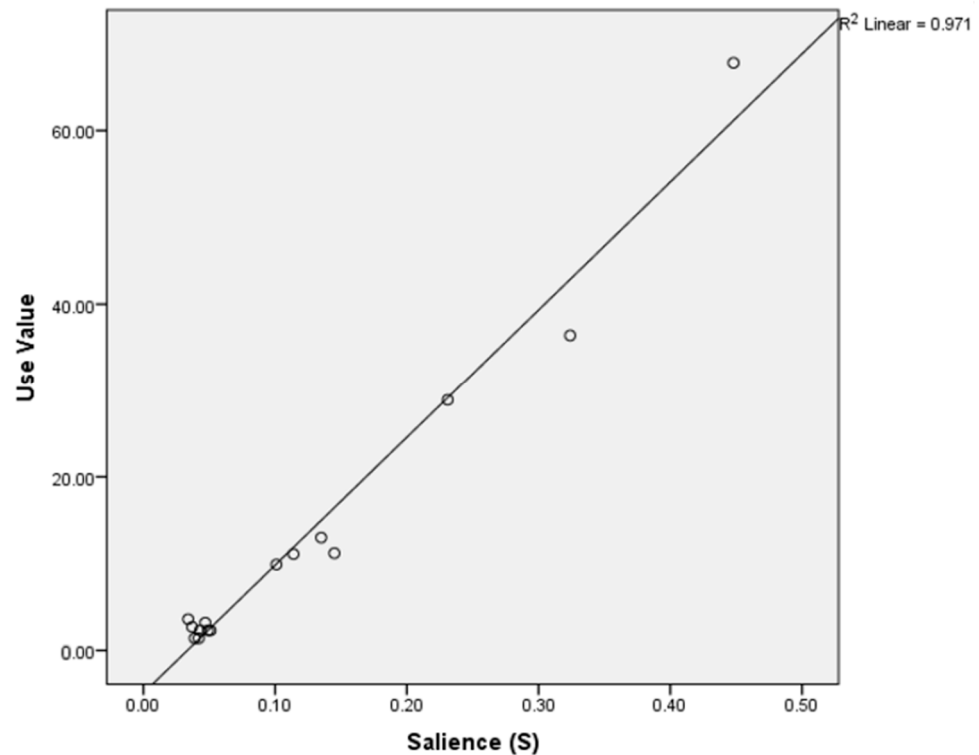
Scientific Names	English Names (Common Names)	Vernacular Names (Tsonga Language)	Overall Saliency
<i>Colophospermum mopane</i>	Mopane	Xanatsi	0.448 <sup>1</sup>
<i>Sclerocarya birrea</i>	Marula	Nkanye	0.324 <sup>2</sup>
<i>Combretum imberbe</i>	Leadwood	Mondzo	0.232 <sup>3</sup>
<i>Combretum molle</i>	Velvet bushwillow	Xikukutsi	0.145 <sup>4</sup>
<i>Diospyros mespiliformis</i>	Jackal berry	Ntoma	0.135 <sup>5</sup>
<i>Berchemia discolor</i>	Brown ivory	Nyiri	0.114 <sup>6</sup>
<i>Cassia abbreviata</i>	Long tail cassia	Lumanyama	0.101 <sup>7</sup>
<i>Spirostachys africana</i>	Tamboti	Ndzhopfori	0.049 <sup>8</sup>
<i>Ficus sycamorus</i>	Sycamore fig	Nkuwa	0.046 <sup>9</sup>
<i>Acacia nigrescens</i>	Knob thorn	Nkaya	0.045 <sup>10</sup>
<i>Ximania caffra</i>	Large sourplum	Ntsengele	0.043 <sup>11</sup>
<i>Dichrostachys cinerea</i>	Sickle bush	Ndzhenga	0.042 <sup>12</sup>
<i>Acacia caffra</i>	Common hook-thorn	Mubvinya-xihloka	0.039 <sup>13</sup>
<i>Strychnos madagascariensis</i>	Monkey orange	Nkwakwa	0.037 <sup>14</sup>
<i>Vachellia karoo</i>	White-thorn	Munga	0.034 <sup>15</sup>

<sup>1-15</sup> W = 0.83, Chi-square = 0.0029, Saliency ranking from highest to lowest (1–15).

**Table 7.** The tree species use value and major uses.

Scientific Names	Gawula	Mahlathi	Nkomo C	Hlomela	Overall UV	Major Uses
<i>Colophospermum mopane</i>	81.4	56.8	65.2	67.7	67.8	A, B, C, E
<i>Sclerocarya birrea</i>	31.4	50	19.6	44.6	36.4	A, B, C, D
<i>Combretum imberbe</i>	38.6	37.8	23.9	15.4	28.9	A, B, C
<i>Diospyros mespiliformis</i>	27.1	1.4	17.4	6.2	13	A, B, C, D
<i>Combretum molle</i>	8.6	8.1	17.4	10.8	11.2	A, B, C
<i>Berchemia discolor</i>	7.1	21.6	10.9	4.6	11.1	A, B, D
<i>Cassia abbreviata</i>	7.1	20.3	4.3	7.7	9.9	B
<i>Vachellia karoo</i>	0	12.2	2.2	0	3.6	A, B, C, E
<i>Ficus sycamorus</i>	5.7	2.7	4.3	0	3.2	A, B, C, D
<i>Adansonia digitata</i>	0	1.4	4.3	6.2	3	B, D
<i>Strychnos madagascariensis</i>	2.9	1.4	2.2	4.6	2.7	A, B, D
<i>Aloe marlothii</i>	0	0	10.9	0	2.7	B
<i>Acacia nigrescens</i>	0	0	0	9.2	2.3	A, C, E
<i>Ximania caffra</i>	1.4	4.1	2.2	1.5	2.3	B, D
<i>Spirostachys africana</i>	4.3	2.7	2.2	0	2.3	B
<i>Grewia monticola</i>	4.3	2.7	2.2	0	2.3	A, C, D
<i>Philenoptera violacea</i>	0	1.4	6.5	0	2	A, B, C
<i>Trichilia emetica</i>	4.3	1.4	0	1.5	1.8	B, D
<i>Euclea divinorum</i>	2.9	2.7	0	1.5	1.8	B, C, D
<i>Dichrostachys cinerea</i>	1.4	0	4.3	0	1.4	A, B, C, E

A = Fuelwood, B = Medicine, C = Construction, D = Fruits, E = Fodder.



**Figure 2.** Scatter plot showing a relationship between use-value and salience (perceived tree species abundance).

## 4. Discussion

### 4.1. Perceived Tree Species Abundance and Use-Value

This study reveals a clear pattern in local people's perceptions of tree species abundance across the study communities in Mopane woodlands. Patterns of woodland resource use and perceptions of tree abundance reflect the principles of ecological apparency theory. Species perceived as abundant, such as *Colophospermum mopane*, *Sclerocarya birrea*, *Combretum imberbe*, *Combretum molle*, and *Diospyros mespiliformis* are largely ecologically apparent and high-value tree species. These findings imply that mopane woodlands perceived species abundance exhibit a broad spectrum of species variation. Similar findings were recorded in mopane woodlands in Mozambique, where the mopane woodlands were found to be highly dominated by mopane species, and other species such as *Combretum* species [17]. In this case, the perceived abundance of the mopane tree species was also highly correlated with its high use-value, reinforcing the link between local perceived tree species abundance and human utilization. In line with these findings, Makhado et al. [8] reported that *Colophospermum mopane* use value correlates with the perceived species abundance in Greater Giyani. The perceived abundance of tree species directly influences local selection and utilization patterns [17]. The findings also resonate with studies by Revermann et al. [31], who reported that the *C. mopane* tree use value is highly associated with the quality of fuelwood, medicines, construction materials, bark for ropes, and numerous other uses.

Findings from this study in the Mopani District reveal that *Colophospermum mopane* and *Combretum imberbe* are among the most frequently utilized tree species, valued for their multifunctional roles in providing fuelwood, construction materials, traditional medicine, and food throughout the year. These species are particularly in high demand throughout the year, especially for fuelwood, highlighting their importance in household energy needs. Furthermore, local communities reported using *C. mopane* and *C. imberbe* to treat a

variety of ailments, including bilharzia, tapeworms, stomachaches, and gout, confirming their significance in traditional medicine. *Sclerocarya birrea* (marula) is second most commonly perceived abundant and highly valued tree species. It is widely used for beverages production, fruits consumption, fuelwood for brick making, medicinal purposes, and cultural ceremonies. Together with *Colophospermum mopane*, *Sclerocarya birrea* are prominent in the mopane woodlands. Its strong cultural significance reinforces local perceptions of abundance, even in areas where intensive harvesting has been observed, such is in Mopani District.

These findings are consistent with those of Urso et al. [32], who noted that mopane woodlands supply a wide range of products year-round, and with Mashabane et al. [33], who similarly observed heavy reliance on these species for fuel and medicinal use. With rising unemployment and poverty levels in South Africa and the broader southern African region, reliance on forest resources such as these is expected to intensify. As Baiyegunhi and Oppong [5] observed, local communities are increasingly transitioning from subsistence use of non-timber forest products to their commercialization as a strategy to alleviate poverty and address economic challenges. The *Vachellia karoo* was perceived as having low abundance, whereas it was recorded as having a high use value with multiple uses. Although *V. karoo* has been recognized as a common encroaching woody plant in South Africa [34], the low perceived abundance may suggest a limited distribution of the species in mopane woodlands. *V. karoo* is widely distributed in rangeland ecosystems [34]. The following species, *Adansonia digitata*, *Aloe marlothii*, *Ximenia caffra*, *Grewia monticola*, and *Philenoptera violacea*, were recorded as having low use values and did not appear among the top species perceived as abundant. This aligns with ecological apparency theory, which predicts lower recognition and use of less apparent species. These species are either patchily distributed, naturally rare, or occur outside their preferred habitats within Mopane woodlands. Moreover, although these species are not perceived as abundant, they nonetheless hold social and cultural significance. However, the influence of human disturbances on these perceptions of abundance should not be overlooked [5].

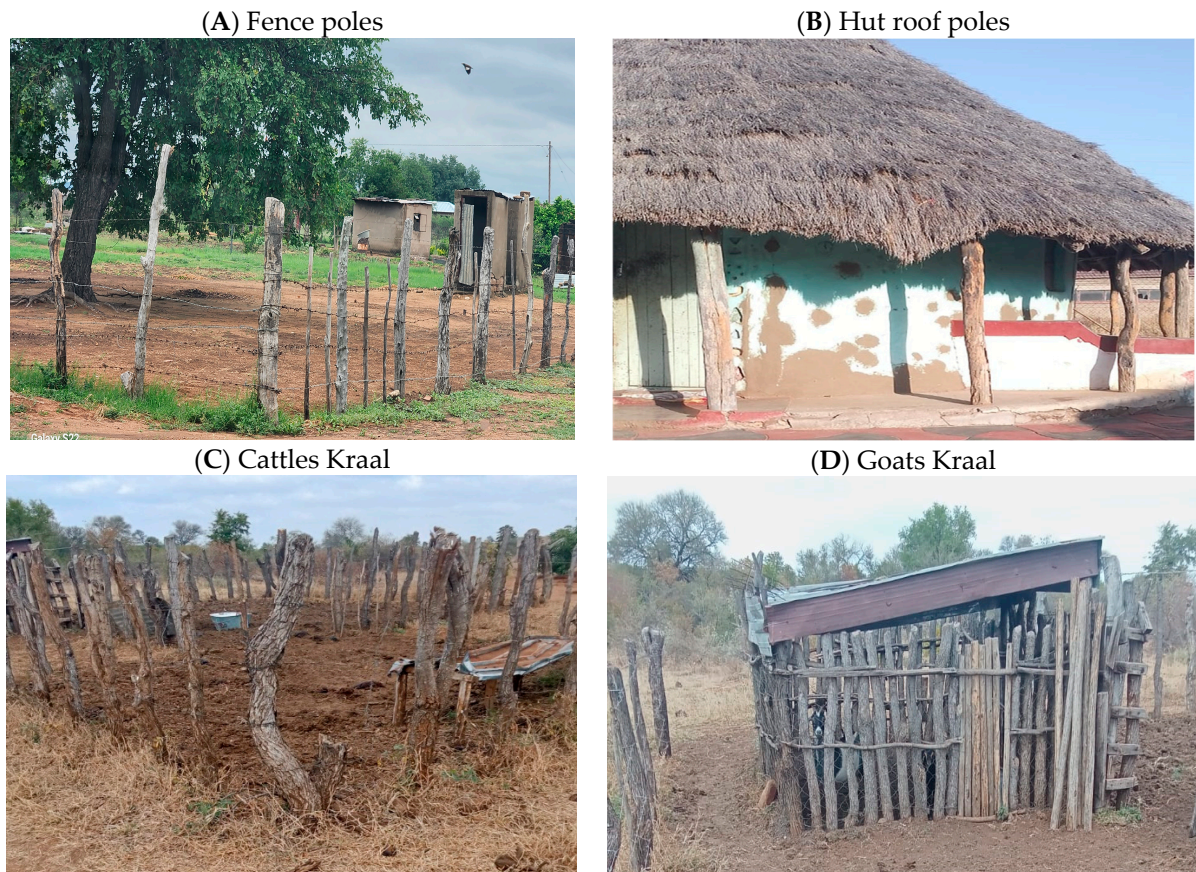
#### 4.2. Utilization of Non-Woody Plant, Animal, and Woody Products in Mopane Woodlands

The current study found that non-woody plant products (NWPPs) play a critical role in the livelihoods of communities living within the Mopane woodlands. The most frequently utilized NWPPs include wild vegetables (e.g., wild spinach), medicinal plants, sweeping materials, wild fruits (e.g., *Sclerocarya birrea*—marula), and thatch grass. Among these, wild vegetables emerged as the most significant NWPP across communities, confirming their role as a key food source. These findings are consistent with Mashabane et al. [33], who identified wild fruits, vegetables, and medicinal plants as dominant NWPPs in the Greater Giyani Municipality. Similar resource-use patterns have also been observed across other Mopane woodland regions in southern Africa [31].

In addition to plant-based resources, the study documented a wide range of non-woody animal products (NWAPs) sourced from Mopane woodlands. The most commonly used NWAPs are mopane worms (*Imbrasia belina* moth caterpillar), fish, bushmeat, birds (e.g., guinea fowl), and honey. Mopane worms were identified as the most significant animal product, both nutritionally and economically. This is in line with Siddiqui et al. [7], who describe mopane worms as the most widely consumed wild insect in Limpopo Province, deeply embedded in local culture and traditions. These edible insects contribute significantly to food security and income generation, especially through informal commercialization.

However, unsustainable harvesting practices, such as cutting branches to collect larvae or harvesting immature worms, pose serious threats to both the mopane worm population and the vegetation that supports them. The cumulative effect of many small, repeated

fires during the mopane worm harvesting and processing period (e.g., cooking, boiling, or roasting) has led to frequent anthropogenic fires in mopane, subsequently altering the fire regimes. Siddiqui et al. [7] note that while sustainable harvesting techniques (e.g., collecting from shrubs or lower branches) are known, they are rarely practiced, exacerbating woodland degradation. The study also explored woody plant products (WPPs), revealing that fuelwood, poles (for fence, house roofs, livestock kraals) (Figure 3), laths, and droppers are among the most heavily relied upon.



**Figure 3.** Multiple use of Mopane woodlands trees in study communities.

Fuelwood was identified as the most significant wood product, underscoring its critical role in household energy, especially for cooking and heating (Figure 4). Similar findings by Nikodemus et al. [35] confirm that communities adjacent to Mopane woodlands largely depend on fuelwood for energy needs. The most preferred tree species for woody products were *Colophospermum mopane*, *Combretum imberbe*, *Sclerocarya birrea*, *Diospyros mespiliformis*, and *Combretum mole*, a pattern echoed in earlier studies [8,36].

Although charcoal production ranked low in this study, traditional leaders expressed rising concern over illegal charcoal operations in several communities. These activities are reportedly causing a decline in mopane vegetation, with knock-on effects on mopane worm availability and increasing foraging distances. This trend mirrors findings in Zimbabwe, where overharvesting of fuelwood and timber has similarly degraded mopane woodlands [4]. In Mozambique, illegal charcoal production has led to widespread degradation of mopane woodland, forcing producers to shift to alternative species, such as *Combretum* spp. [37]. Despite the perceived abundance of other species, *C. mopane* remains the preferred species for both firewood and charcoal due to its high-quality, slow-burning properties [38].



**Figure 4.** Stacks of fuelwood harvested by the local communities of Mopane woodlands.

Addressing the unsustainable exploitation of Mopane woodland products requires multi-stakeholder cooperation, including licensing and the legal commercialization of natural resources. Restrictive conservation policies have proven largely ineffective in the face of widespread poverty and unemployment. Traditional leadership structures, once central to woodland governance, are now weakened, and roles among key stakeholders remain unclear [5]. To counteract degradation, there is a pressing need to establish Mopane woodland user associations, improve licensing systems, and promote co-management models. As Sinthumule [20] emphasizes, successful conservation hinges on collaboration between local communities, traditional leaders, and government institutions.

## 5. Conclusions

The findings reveal that communities in the study area possess rich and reliable ecological knowledge regarding the perceived abundance and uses of tree species in Mopane woodlands. *Colophospermum mopane*, *Sclerocarya birrea*, and *Combretum imberbe* were identified as the most perceived abundant and high-value species. Tree species with higher use values showed a positive correlation with perceived abundance, supporting the ecological apparency hypothesis of the study. More apparent species were associated with greater use value and higher perceived abundance. Most forest products were collected from species perceived as abundant, indicating potential use pressure on these dominant tree species in Mopane woodlands. The most frequently collected resources included firewood, mopane worms, medicinal plants, wild vegetables, poles, and fish. Among these, firewood emerged as the primary woody forest product, while mopane worms and wild vegetables were the most significant non-woody animal and plant products, respectively. Future research should focus on conducting ecological inventories of Mopane woodlands to validate community-based perceptions of species abundance.

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