



Research Article

# Livelihood benefits from commercialisation of mopane worms (*Imbrasia belina*) in the Mopani District Municipality, Limpopo Province of South Africa

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## Abstract

Mopane worms have traditionally been harvested for subsistence purposes, however, in recent times, there has been increased commercialisation of these worms. In Muyexe and Nsavulani villages (falling under Mopani District), local communities have been selling mopane worms for the past two decades. A survey was undertaken in these two villages in June and July 2023 to document the process involved in the commercialisation of mopane worms—from raw material harvesting to a commodity sold to generate cash income, and to assess the importance of the trade for livelihoods and poverty alleviation of households. Interview-administered questionnaires were used as the main data collection tool, and systematic random sampling was used to select 161 households in Muyexe village and 82 households in Nsavulani village. The questionnaire that included closed- and open-ended questions covered the socio-economic profile of respondents, mopane worms' availability and procurement, processing of mopane worms, marketing, trading of mopane worms and livelihood benefits from selling mopane worms. Closed-ended questions were analysed using the Statistical Package for Social Sciences, while open-ended questions were analysed using thematic content analysis. The study found that most of the harvesters in Muyexe (69% n = 111) and Nsavulani (59% n = 48) villages were females. Most harvesters in Muyexe (97%; n = 156) and Nsavulani villages (98%; n = 80) preferred degutting mopane worms at home, whereas only five and two respondents in Muyexe and Nsavulani villages, respectively, degut them in the harvesting fields. The researcher found that mopane worms are harvested for both household consumption and trade—this is in line with Sustainable Development Goal 1 (no poverty) and 2 (zero hunger). Most harvesters in Nsavulani village who trade mopane worms reported making between R2,100 (\$113.79) and R3,000 (\$162.55), whereas most harvesters in Muyexe village make between R1,000 (\$54.18) and R2,000 (108.37) per season. The study found that 55% of households in Muyexe village and 70% in Nsavulani village derive income only from mopane worm sales. Although the income earned from the sale of mopane worms is seasonal, it is highly appreciated by communities and plays a significant role in alleviating poverty and improving their lives and livelihoods.



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**Key words:** Caterpillars, communities, harvesting, marketing, mopane woodlands, nutritious, poverty alleviation, trading

## 1. Introduction

Like other edible insects and caterpillars, the mopane worm (*Imbrasia belina*) is an important source of protein in southern African countries. This non-timber forest product (NTFP) caterpillar is herbivorous and feeds mostly on the leaves of the mopane tree (*Colophospermum mopane*) (Mpuchane et al. 2000; Akpalu et al. 2009). The mopane woodlands stretch from the northern parts of South Africa into Zimbabwe, Zambia, western Mozambique and northeastern Botswana. They also extend from the south-western parts of Angola into northern Namibia (Illgner and Nel 2000; Kwiri et al. 2020). According to Mapaure (1994), mopane woodlands in southern Africa cover an area of approximately 550,500 km<sup>2</sup>. As Stack et al. (2003) have noted, the majority of these regions are located in areas unsuitable for the cultivation of crops and where local communities experience a high level of vulnerability to food insecurity. As a result, harvesting of mopane worms plays a significant role in building food security in these regions because the processed (dried) mopane worms can be stored for many months (Baiyegunhi et al. 2016; Nantanga and Amakali 2020). As documented by many scholars, mopane worms are also harvested for their nutritional value (Headings and Rahnema 2002; Mnisi et al. 2022; Ruzengwe et al. 2023; Madi-mutsa et al. 2023) which can help to alleviate nutritional deficiencies/diseases in rural communities.

Mopane caterpillars are harvested in Botswana, South Africa and Zimbabwe from December to January, and then again from April to May following good rains (Mpuchane et al. 2000; Gondo et al. 2010; Nantanga and Amakali 2020). In these regions of southern Africa, the mopane worm is bivoltine (that is, it produces two generations per rainy season). However, in Namibia, the mopane worms are univoltine (meaning they come only once a year) (Thomas 2013). Whereas harvesting of mopane caterpillars by rural families was traditionally for their respective household's domestic consumption (Kozanayi and Frost 2002; Stack et al. 2003; Makhado 2008), over recent decades there has been an increase in the demand for mopane worms, and this has led to the increased commercialisation of these worms (Mpuchane et al. 2000; Stack et al. 2003; Mogomotsi et al. 2018). As Oppong (2013) has noted, mopane worm commercialisation occurs when the household production system shifts from harvesting caterpillars for household consumption to harvesting for both consumption and the market.

Over recent decades, mopane worms have gradually become an important trading commodity (Mapaure 1994; Manditsera et al. 2022) in formal and informal markets (Kozanayi and Frost 2002). Local-level trade is driven by a greater need for cash as people become more integrated into a market economy and face economic hardship and unemployment (Moruakgomo 1996). Evidence shows that mopane worms are exported (traded) to overseas countries such as the United States of America and Korea (Mpuchane et al. 2000). There are also vibrant cross-border networks trading mopane worms throughout southern Africa, with evidence of marketing chains extending from southern Zimbabwe and eastern Botswana to South Africa, Zambia and the Democratic Republic of the Congo (Illgner and Nel 2000; Kozanayi and Frost 2002; Gondo et al. 2010). Thomas (2013) has also reported a cross-border trade of mopane worms from Angola to Namibia. In addition, mopane caterpillars are traded na-

tionally within the main producing countries (Botswana, Namibia, South Africa and Zimbabwe). Of interest to the discussion of this paper is local-level commercialisation of mopane worms within the main producing countries.

Several studies conducted in Zimbabwe (Kozanayi and Frost 2002; Stack et al. 2003; Gondo et al. 2010; Manditsera et al. 2022), Botswana (Moruakgomo 1996; Mogomotsi et al. 2018) and Namibia (Thomas 2013; Togarepi 2020) have touched on aspects of the commercialisation of mopane worms. The studies have revealed that the harvesting of mopane worms has become increasingly significant to rural people as an income-generating activity. In some cases, traders (harvesters) (particularly in rural areas of Botswana, Zimbabwe and Namibia) do in-kind exchange (bartering) of their hard-gathered mopane worms for food, alcohol, or old clothes (Kozanayi and Frost 2002; Thomas 2013; Mogomotsi et al. 2018). It is important to note that trading of mopane worms is not commercialisation because commercialisation is a complex process that involves several phases or stages. In South Africa, although there is still limited literature on the commercialisation of mopane worms, few studies have been undertaken. A study by Makhado et al. (2009) on the contribution of woodland products to rural livelihoods in the Giyani area of the Limpopo Province touched on some aspects of mopane worm trade; however, detailed information on the process of commercialisation by local communities was not provided. Baiyegunhi and Oppong (2016) used a cross-sectional dataset in Limpopo Province to identify socio-economic factors influencing mopane worm commercialisation. The emphasis of the latter study was not on the commercialisation of mopane worms per se but on factors influencing people to sell or trade mopane worms.

More recently, Sekonya et al. (2020) in their study have explained governance and access to mopane caterpillars in the context of commercialisation. The commercialisation process from harvesting raw material to marketing and trading of mopane worms remains poorly understood. This study aims to fill this gap in the context of South Africa. The study aims to document the process involved in the commercialisation of mopane worms from raw material harvesting into a commodity that is sold to generate cash income; the study further aims to assess the importance of the trade for poverty alleviation and household livelihoods. The main research questions guiding the discussion of this paper include: first, what is the process involved in commercialising mopane worms from raw material harvesting into a commodity that is sold to generate cash income? Second, what is the importance of the trade for household livelihoods and poverty alleviation? The analysis of commercialisation of mopane worms is also not only important in minimising unemployment rate but also contributes towards improving the lives and livelihoods of people, food security and poverty alleviation, particularly in the context of developing countries. In addition, understanding the commercialisation of mopane worms is significant as it can influence government and policymakers to formalise the mopane worm sector for the benefit of the traders.

## 2. Commercialisation as a theoretical lens

There is no single acceptable definition of commercialisation. This is because the process of commercialisation is diverse; as a result, a wealth of definitions

of commercialisation have been presented in the literature (Pellikka 2014). For instance, commercialisation refers to a process where intellectual property is licensed using rights, knowledge sharing and commercial gains (generating profit) to the intellectual property holder (Chandra and Liaqat 2019). In regional and innovation studies, commercialisation is commonly defined as the final stage or phase of the innovation process (Mansfield 1988). This starts with the concept/product, strategic and tactical planning, marketing activities concerning the product, launch and interactive activities with potential buyers and other relevant players (Aarikka-Stenroos et al. 2014). As Pingali and Rosegrant (1995) have noted, the idea is to ensure that an innovative firm can accrue income from its new product, service, concept, or technology.

According to Mitchell and Singh (1996), commercialisation refers to the process of acquiring ideas, enhancing them with additional knowledge and developing and manufacturing products that can be sold in a market. From these definitions, various stages of commercialisation include production, distribution, marketing, sales or trade and customer support (Ahenkan and Boon 2010; Pellikka 2014). A fundamental concept in economics trade, which entails the purchase and sale of goods and services as well as the payment made by a buyer to a seller (Howse et al. 2005) is part of commercialisation process. In a different context, trading may involve parties exchanging goods or services (Ord 2015) and within an economy, producers and consumers may engage in trade (Rubenstein 2018). From this explanation, it can be deduced that trade is not commercialisation, rather, one of the stages of commercialisation of products. Commercialisation of natural products may occur in urban, peri-urban or rural areas. Of interest to the discussion of this paper is the commercialisation of mopane worms (an NTFP) in the context of a rural setting. Commercialisation of mopane worms is not just a single stage as in the case of trade but rather a complex process with several stages or phases that are interconnected rather than isolated (Fig. 1). For instance, when a person has harvested mopane worms, they need to process, market and sell them to make an income. Such income generated through selling mopane worms can help to alleviate poverty (Baiyegunhi et al. 2016; Hlongwane et al. 2021).



**Figure 1.** Conceptual framework of commercialisation of mopane worms in Mopani District Municipality in Limpopo Province of South Africa.

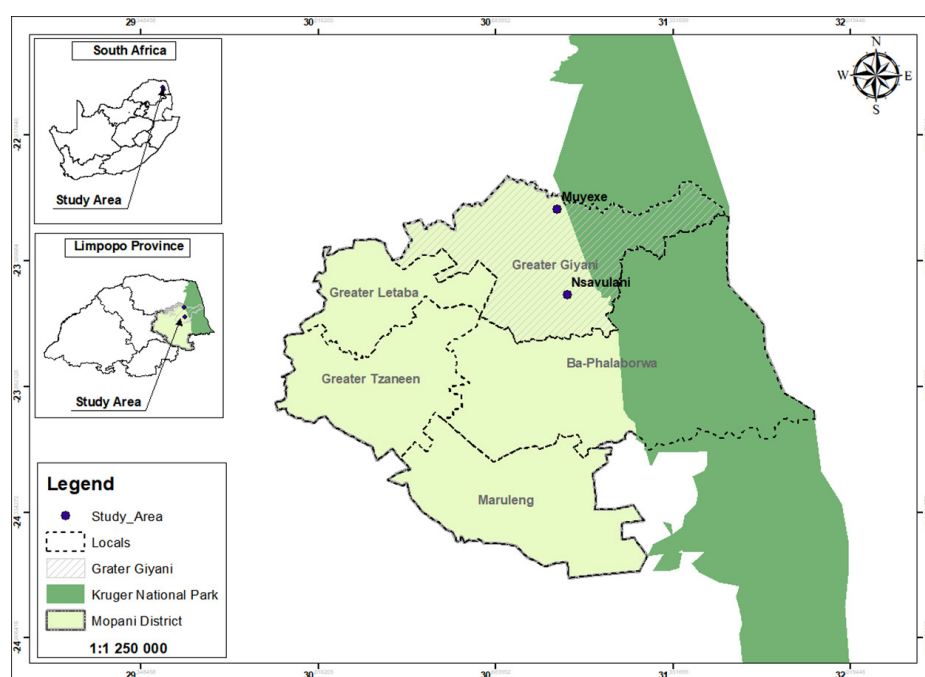
The concept of commercialisation provides a useful lens to understand the value chain of mopane worms and the importance of trade to peoples' livelihoods and poverty alleviation. The rationale for natural product commercialisation is often to overcome poverty, economic hardship and high rates of unemployment (Shackleton 2004). By increasingly relying on natural products (such as mopane worms), it is hoped that poor and disadvantaged people will gain income and short-term employment opportunities as with other NTFPs (Neumann and Hirsch 2000; Marshall et al. 2003; Zhou et al. 2013; Lamichhane 2022; Gu 2023). This may help to improve their lives and livelihoods.

### 3. Methodology

#### 3.1. Study area

The area selected for study was Muyexe (23°11'42.4"S, 30°54'57.49"E) and Nsavulani (23°31'0.48"S, 30°57'17.28"E) villages (Fig. 2). According to the 2011 Census, Muyexe covers an area of 3.42 km<sup>2</sup> with 826 households and a population of 3,228, whereas Nsavulani is 2.53 km<sup>2</sup> with 548 households and a population of 2,014. Both these villages are close to Kruger National Park and are therefore surrounded by a fence aiming to control the spread of diseases from wildlife from the park to domestic animals in communal lands (Sinthumule 2024). The majority of people in these two villages live below the poverty line and inhabitants depend mainly on subsistence farming, child grants and old age pensions. These two villages fall under Greater Giyani Local Municipality in the Mopani District Municipality in the Mopani District Municipality. The Mopani District Municipality is a Category C municipality located within the north-eastern side of Limpopo Province. Category C municipality is a municipality that has municipal executive and legislative authority in an area that includes more than one municipality. It is bordered by Zimbabwe in the north and Kruger National Park (Shingwedzi Camp) and Mozambique in the east. Mopani District Municipality (one of the five districts in Limpopo Province of South Africa) comprises an area of 20,011.09 km<sup>2</sup>. The local municipalities in Mopani are Ba-Phalaborwa (7,489km<sup>2</sup>), Greater Giyani (4,172 km<sup>2</sup>), Greater Letaba (1,891 km<sup>2</sup>), Greater Tzaneen (2,897 km<sup>2</sup>) and Maruleng (3,563 km<sup>2</sup>) Local municipality.

Mopani District Municipality is part of the Great Limpopo Transfrontier Park between South Africa, Zimbabwe and Mozambique. The vegetation is typical semi-arid savanna, and according to Mucina and Rutherford (2006), is classi-



**Figure 2.** Location of Muyexe and Nsavulani villages, falling under Giyani Municipality in Mopani District in Limpopo Province of South Africa.

fied as SVmp6 (Lowveld Rugged Mopane Veld). Vegetation is relatively open, particularly outside the Kruger National Park. The district is named for the abundance of *Colophospermum mopane* (the mopane tree) (CoGTA, Mopani District Municipality 2020) the area receives an average rainfall of 500 mm per annum and about 85% of the rain is received during summer (between October and March) (Nembilwi et al. 2021). Mopani District is categorised as a sub-tropical region with warm temperatures all year round (Fitchett et al. 2016) and frost rarely occurs in the district (CoGTA, Mopani District Municipality 2020). Frequent seasonal drought (recurring about every 3–4 years) (Nembilwi et al. 2021) limits arable dryland production in the area. According to the Department of Water and Sanitation (2011), the district falls within both the Letaba (covering approximately 13,400 km<sup>2</sup>) and Olifants Catchment areas (covering approximately 54,550 km<sup>2</sup>).

### 3.2. Data collection

In compliance with the need for ethical research, this study was approved by the University of Johannesburg, Faculty of Science and an ethical clearance certificate was issued before the research proceeded (Ethics Reference Number: 2022-11-18/Sinthumule). Permission to conduct this research was also obtained from the local authorities in Muyexe and Nsavulani villages. In addition, respondents were asked for their permission before they were interviewed. In line with the eight principles of the Protection of Personal Information Act (Government Gazette 2013), participants were informed that participation in the study was voluntary, there would be no remuneration and that they were free to withdraw from the study at any stage of the research should they wish to do so. They were also made aware that their participation was (and would remain) confidential and their identity would not be revealed; hence, in this study all respondents are referred to in a way that maintains their anonymity. All the respondents who participated in the study were asked to sign a written consent form. However, out of the 243 respondents who participated in the survey, 225 signed a written consent, whereas the remaining 18 gave a verbal consent because they could not write.

Data supporting this study was collected through interview-administered questionnaires and observations. A probability systematic random sampling approach was used to select households that were interviewed. This approach was followed to avoid the potential for human bias because household selection happens using a sampling interval (Walliman 2011). Questionnaires were administered during the week (Monday to Friday). When no one was available to be interviewed at the time of the survey in a selected household, the neighbouring household (to the left or right) was selected to replace the original household. The desired sample size was determined using well-known Taro Yamane's formula (Yamane 1967) as indicated below.

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

Where  $n$  represents the sample size;  $N$  represents the total population;  $e$  represents the level of significance; and  $1$  represents a constant value.

Even though 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 a 5% margin of error. Similarly, in Nsavulani village with 548 households, only 102 households are found along the *C. Mopane* belt (Table 1).

**Table 1.** Number and percentage of sampled households in Muyexe and Nsavulani villages.

Villages	Total households	Sampled households	Percentages
Muyexe	826	161	19.5
Nsavulani	548	82	15

As a result, a sample of 82 households was selected at a 95% confidence level and a 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. Systematic random sampling requires the selection of samples based on special intervals (Walliman 2011). The questionnaires in this study were administered in five consecutive households after which the sixth household was omitted. The questionnaire targeted household heads, namely the man or woman who assumed responsibility for the household (Budlender 2003). 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 the sampling interval.

In line with White et al. (2005), the questionnaire combined closed- and open-ended questions. Closed-ended questions were incorporated to get accurate responses from the respondents, whereas open-ended questions were included to allow informants to express themselves. A questionnaire was administered in the local language (Tsonga) through three research assistants who were employed and trained for two days before they started the survey. The questionnaire covered the socio-economic profile of respondents, knowledge and benefits of mopane worms, reasons for entering mopane trade, production, processing and income, and sustainability issues. Following Willis (2016) and Bernard (2017), survey questions were pretested first on three research assistants and then on 20 respondents from Thomo village. Pretesting is a method of checking that questions work as intended and are understood by those individuals who are likely to respond to them (Hilton 2017). After pretesting, it was found that all the questions were clear and unambiguous, although the information gathered during pretesting was excluded from the study results. The questionnaires were administered in Muyexe and Nsavulani villages in June and July 2023. The total response time for each interview was approximately 30 minutes. Before administering the questionnaire, the research assistants were instructed to follow cultural norms that included their introduction, the rationale of the questionnaires and their intended purpose, and to inform the respondents that their participation is voluntary and that they will remain anonymous. To enhance the validity and the reliability of the methods used, trian-

gulation was done in this study. According to Denzin (1978), triangulation is the process of combining different approaches or methods to study the same phenomenon. In this study, triangulation was used to relate and validate data collected through various methods, namely, interviews, questionnaires and observation. Taken together, these three methods provided a good picture of the process involved in the commercialisation of mopane worms from raw material harvesting to a commodity sold to generate cash income and the importance of trade for livelihoods and poverty alleviation.

### 3.3. Data analysis

The collected data was tabulated in Microsoft Office Excel 2016. Closed-ended questions were analysed using Statistical Package for Social Sciences (SPSS), version 25 for Windows. Descriptive statistics were used to summarise the questionnaire response data set. In addition, Chi-square ( $X^2$ ) tests were applied using SPSS to find out if the responses occurred with equal probability. Differences were significant at 5%. Open-ended questions were analysed using thematic content analysis—a qualitative analytic method of “identifying, analysing and reporting patterns (themes) within data” (Braun and Clarke 2006). The transcribed notes were read critically to gain understanding. The interview quotations were tabulated on Microsoft Excel and key phrases were highlighted in different colours according to categories. This process allowed us to identify the main points and common meanings that were repeated from the data. In the end, patterns and themes emerging from the data were identified. In some cases, episodes were narrated, and cases were described, often in the exact words used by the informants to communicate to the reader the vividness of the situation studied without altering the material recorded (Corbetta 2003).

## 4. Results

### 4.1. Demography

The questionnaire sample in Muyexe village consisted of 31% of male participants and 69% of female participants ( $X^2 = 23.11$ , d.f. = 1,  $P < 0.05$ ), ranging from 19 to 78 years of age (mean = 44.6, SD = 20.56). In Nsavulani village, 41% of the sample were male participants and 59% were female participants ( $X^2 = 2.39$ , d.f. = 1,  $P < 0.05$ ), and were between 22 and 75 years of age (mean = 41.45, SD = 19.86). The study was conducted during weekdays when many of the men in the communities were at work; thus, women were the respondents for most households both in Muyexe and Nsavulani village. Regarding the age of respondents or harvester, in Muyexe village, 15% were between 18–30 years old, 45% were between 31 and 50 years old, 22% were 51 and 60 years old, and the remaining 19% were above 61 years old ( $X^2 = 15.6$ , d.f. = 4,  $P = 0.004$ ). Similarly, respondents or harvesters significantly varied in Nsavulani village with 20% between 18–30 years old, 41% between 31 and 50 years old, 17% between 51 and 60 years old, and the remaining 22% above 61 years old ( $X^2 = 1.66$ , d.f. = 4,  $P = 0.798$ ). Of the respondents from Muyexe village who participated, 44% ( $n = 71$ ) were married, 35% ( $n = 57$ ) were single, and the remaining 20% ( $n = 33$ ) were widowed ( $X^2 = 13.76$ , d.f. = 2,  $P < 0.05$ ). Similarly, in Nsavulani village, the

majority (52%; n = 43) were married, 35% (n = 29) were single, and the remaining 13% (n = 10) were widowed ( $X^2 = 20.07$ , d.f. = 2,  $P < 0.05$ ). Unemployment was generally high in both villages, with only 37% employed in Muyexe village ( $P < 0.05$ ) and just 9% employed in Nsavulani village ( $P < 0.05$ ). Thus, a wide range of people, including unemployed, employed, youth, married and elderly people, are involved in the mopane worm business (Table 2).

**Table 2.** Socio-economic profile of the respondents in Muyexe (n = 161) and Nsavulani (n = 82) villages under Giyani Local Municipality in Mopani District, Limpopo Province of South Africa.

Categories	Class	Muyexe (%)	Nsavulani (%)
Age	18–30 years	15	20
	31–40 years	14	24
	41–50 years	31	17
	51–60 years	22	17
	> 61 years	19	22
Gender	Male	31	41
	Female	69	59
Marital status	Married	44	52
	Single	36	35
	Widow	20	13
Education	None	19	26
	Primary	24	18
	Secondary	52	51
	Tertiary	06	05
Occupation	Unemployed	55	70
	Employed	37	09
	Self-employed	07	21
Sources of income	Formal employer	06	05
	Pension	20	25
	Child grant	19	30
	Part-time job	55	40
Number of years staying in the village	0–5	11	17
	6–10	07	13
	11–15	12	09
	16–20	00	00
	> 20	70	61

All employed participants were with the Expanded Public Works Programme, which is a government programme aimed at providing poverty and income relief through temporary work for the unemployed. In terms of education, approximately half of the respondents in Muyexe village (52%; n = 84;  $P < 0.05$ ) and Nsavulani village (51%; n = 42;  $P < 0.05$ ) had secondary education. The majority of people in Muyexe (70%) and Nsavulani (61%) had stayed in the area for more than 20 years. Furthermore, in Muyexe village, the majority of households (73%) had up to five family members, 24% had between six and ten members, and the remaining 4% had between 11 and 15 family members ( $X^2 = 121.65$ , d.f. = 2,  $P < 0.05$ ). Similarly, of the respondents who participated in Nsavulani village, 72% had up to five family members, 27% had between six and ten members, and the remaining 1% had between 11 and 15 family members ( $X^2 = 60.09$ , d.f. = 2,  $P < 0.05$ ).

## 4.2. Mopane worms' availability and procurement

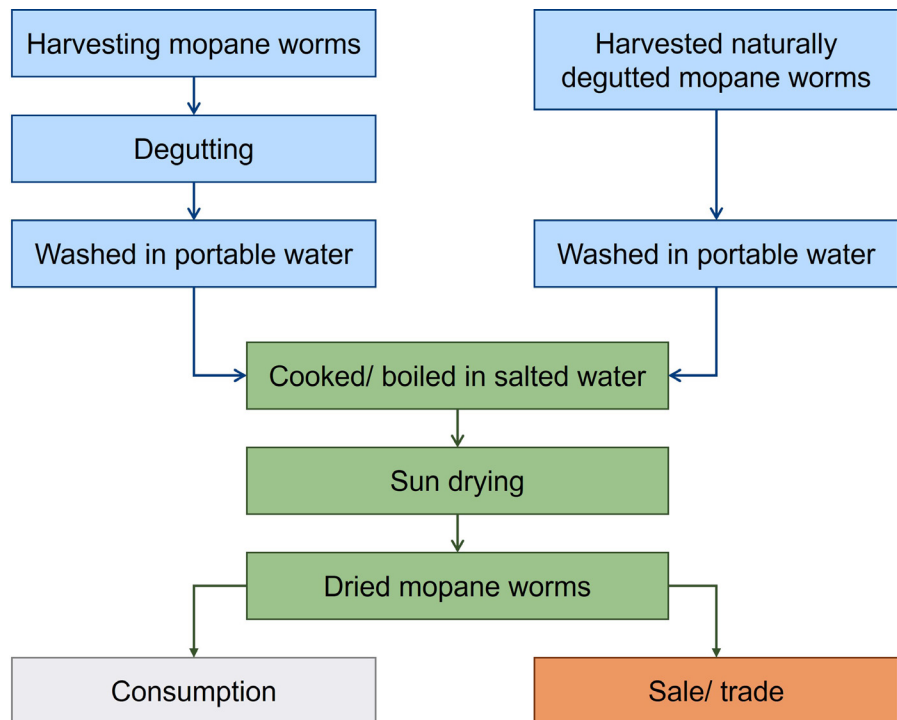
When asked about the seasons of mopane worms, all respondents in both villages were aware that caterpillars were widely harvested in March/April and December. The most common method of collecting or harvesting mopane worms includes picking them by hand from the trees and from the ground. Approximately 24% of respondents in Muyexe village had been harvesting mopane worms for 0–10 years, 17% for 11–20 years, and the remaining 58% for > 20 years ( $X^2 = 46.6$ , d.f. = 2,  $P < 0.05$ ). In Nsavulani village, 18% of respondents had been harvesting worms for 0–10 years, 18% for 11–20 years, and the remaining 63% for > 20 years ( $X^2 = 33.4$ , d.f. = 2,  $P < 0.05$ ). Thus, the majority of the respondents in both villages had been harvesting mopane worms for more than twenty years. When respondents were asked how they transported mopane worms (degutted or non-degutted) back home, in Muyexe village, 60% indicated they carry them on their heads using buckets or 50 or 80 kg maize meal bags, 10% reported they use a wheelbarrow, and the remaining 30% indicated that they hire a car ( $X^2 = 60.2$ , d.f. = 2,  $P < 0.05$ ). In Nsavulani village, 83% reported that they carry them on their heads, 6% indicated that they use a wheelbarrow, and the remaining 11% stated that they hire a car ( $X^2 = 91.05$ , d.f. = 2,  $P < 0.05$ ). It is important to note that mopane worms are collected less than a kilometre, thus, not far from where harvesters stay in both villages.

Most respondents' surveys reported leaving home at 05:00 in the morning for harvesting, however, some noted that they leave as early as 03:00 in the morning. Respondents indicated that if they did not leave early in the morning, they would not have adequate time for processing the mopane worms. In the harvest season, the average time spent harvesting per day was four hours. Those who harvested and degutted mopane worms at the site (that is, in the bush) spent an average of eight hours per day in the harvest season. All respondents perceived that there were sufficient mopane worms to meet demand each season; however, respondents noted that the biggest threat to mopane worm availability appeared to be the use of mopane trees for fuelwood, combined with the clearance of land for agriculture and infrastructural development.

## 4.3. Processing of mopane worms

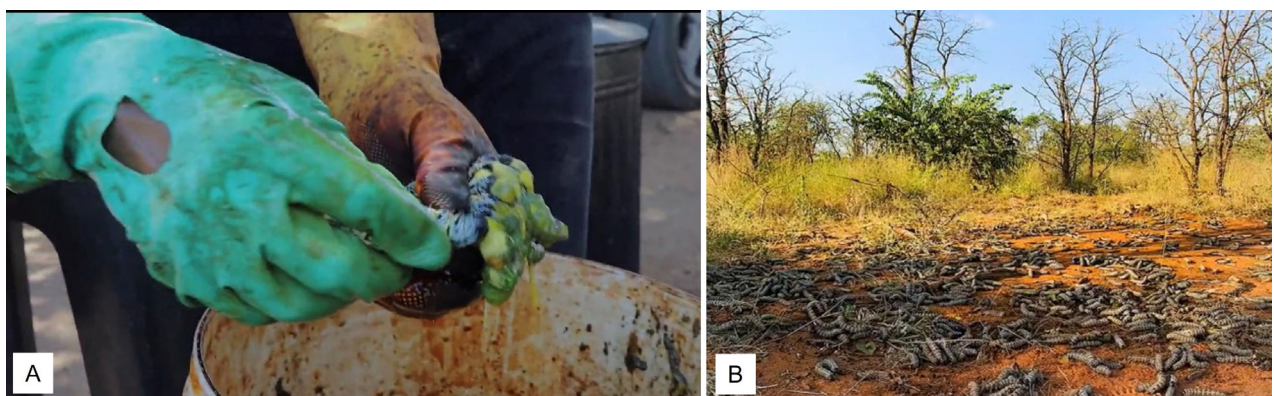
When respondents in Muyexe and Nsavulani were asked about the steps followed in processing mopane worms, all of them were aware of the process (Fig. 3). Some of them have been processing mopane worms for more than 20 years. In the first step of processing, harvesters separate the worms that still have their guts from the naturally degutted mopane worms (the fully grown caterpillars do not require degutting because they have empty guts).

Thus, the harvesters generally put them in two different containers. The bodies of the old caterpillars are filled with yellow nutritive material that is preferred by consumers. The worms that still have their guts in the other container are degutted—a process that involves removing the innards or intestine. This is the most difficult and labour-intensive part of processing because each worm is squeezed individually, and the gut content is removed (the yellow nutritive material or substance that is preferred by consumers is not removed). The squeezing of mopane worms is done by hand, and most of the respon-



**Figure 3.** Mopane worm processing followed by communities in Muyexe and Nsavulani villages.

dents in Muyexe (97%; n = 156) and Nsavulani villages (98%; n = 80) preferred degutting them at home whereas only five and two respondents in Muyexe and Nsavulani villages respectively degut them in the harvesting fields. Those who are responsible for harvesting mopane worms are also responsible for degutting them on the day they were harvested. Harvesters indicated that at least a bucket of 20 litres was filled and transported to the household by those who degut mopane worms at the point of harvesting whereas up to 40 litres (two 20 litres buckets) was transported to the household by those who carry whole (not degutted, but requiring degutting) mopane worms to the households. In the process of squeezing, their hands are discoloured by the body fluids of the caterpillars (Fig. 4A).



**Figure 4.** Processing of mopane worms **A** Process of degutting mopane worms by hand in Muyexe and Nsavulani villages **B** Mopane worms crawling on the ground after exhausting the leaf supply on the mopane trees.

To avoid damage to their hands, some respondents (less than 5% in both villages) indicated that they use gloves. The degutting stage is crucial as it determines the quality of the processed mopane worm, with the ones not degutted properly being of poor quality. The next step after degutting is to wash the mopane worms with potable water in a container to remove all dirt and unwanted materials (some of the caterpillars are collected on the ground, having dropped from the mopane trees once the leaf supply is exhausted) (Fig. 4B).

Some respondents indicated that they use a hand-held rake to gather mopane worms together. In the process, dirt and unwanted materials (including livestock dung) may be collected with the mopane worms. After washing the worms, they are boiled in salty water, after which they are dried in the sun (depending on the weather conditions) for two or three days. However, some respondents indicated that instead of drying all the mopane worms, they keep some in the deep freeze to keep them fresh for consumption at the household. After drying, the mopane worms are ready for consumption and selling. They can be eaten raw as a crunchy snack after drying, or they can be soaked in water to rehydrate and cooked with onions, tomatoes, soup and spices. They can be consumed alone, but they are normally consumed with thick porridge.

#### 4.4. Marketing

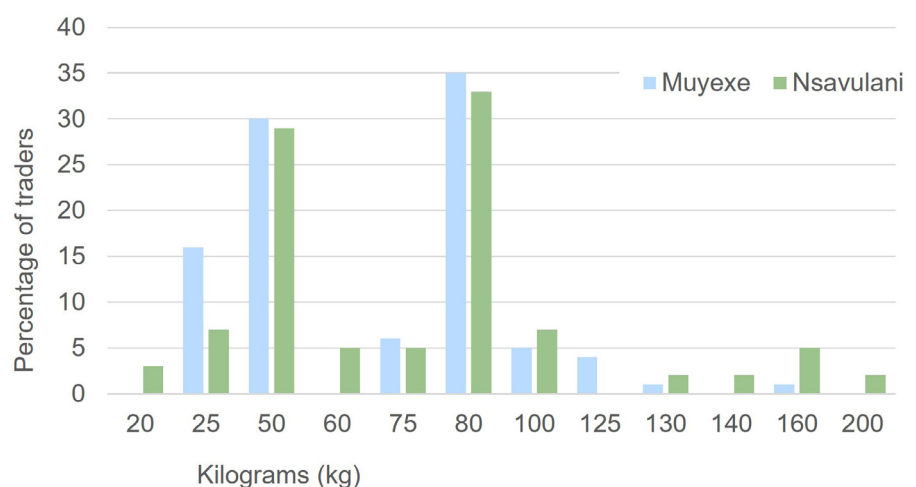
Although mopane worms were originally collected for personal consumption at home, over the past three decades, they have become an important commodity that is sold at a market for a price. Some of the traders indicated that they sell their mopane worms from their homes, whereas some sell mopane worms along major highways near their villages. When respondents were asked how they market their mopane worms, in Muyexe village, 49% (n = 39) had regular customers, 44% (n = 35) indicated that they do not market their products, and the remaining 6% (n = 5) indicated that they used social media (WhatsApp and Facebook). In Nsavulani village, 59% (n = 34) had regular customers, 36% (n = 21) indicated that they do not market their products, and the remaining 5% (n = 3) indicated that they used social media (WhatsApp and Facebook). In Muyexe village, traders (both with regular customers and those who do not market their products) indicated that they sell mopane worms using 20 or 25 litres of buckets at their homes. As one respondent narrated, "Each year I have special orders from my regular customers who phone way in advance and tell me about the quantity of mopane worms they need. When it is mopane worm season, I know the number of buckets I need to fill to ensure that I meet the demand". In Nsavulani village, 36% of traders who do not market their products indicated that during the mopane worm season, they sell mopane worms (using 20 or 25 litres buckets) along the highway that passes through their village whereas those who have regular customers wait for their customers to come and buy at their homes. Thus, the traders do not use public transport (including minibus taxis or buses) to transport their mopane worms from their homes to the markets in urban areas. Rather, respondents from the two villages indicated that they sell their caterpillars in their villages. Thus, there was no cost to marketing and transportation of mopane worms.

#### 4.5. Trading of mopane worms

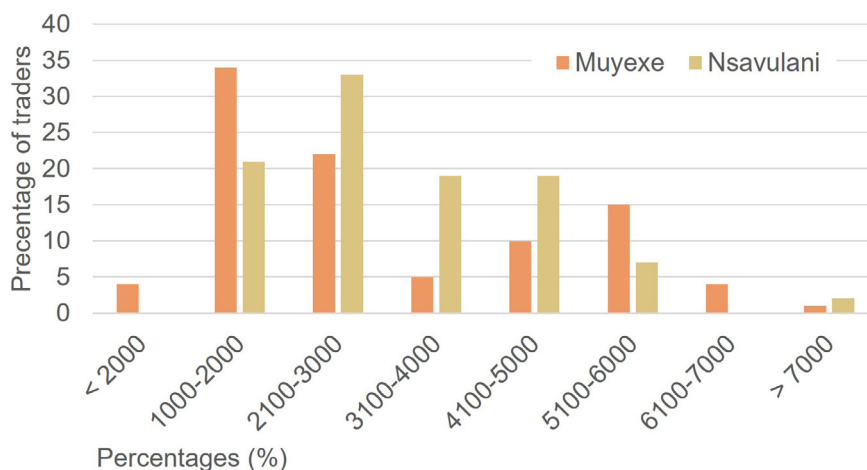
This study found that mopane worms served a dual purpose in the study area. First, they were harvested for household consumption. In all, 51% (n = 82) in Muyexe village reported harvesting mopane worms for household consumption only as compared to 29% (n = 24) in Nsavulani village. Second, mopane worms were reported to be harvested for both household consumption and trade in many households. This is in line with the United Nations Sustainable Development Goal (SDGs) 1 (no poverty) and 2 (zero hunger). A total of 49% (n = 79) in Muyexe village noted that they harvest mopane worms for both household consumption and trade, as compared to 71% (n = 58) in Nsavulani village. Of the 49% of respondents who stated that they harvest mopane worms for consumption and trade in Muyexe village, the majority of the respondents (35%, n = 28) reported harvesting 80 kg sack per household per season ( $P < 0.05$ ). Similarly, in Nsavulani village, of the 58 respondents who harvested mopane worms for consumption and trade, 33% (n = 19) harvested 80 kg sack per household per season ( $P < 0.05$ ) (Fig. 5).

When respondents were asked about the prices of mopane worms, they indicated that there were no fixed prices. Rather, the price is negotiable, and a bucket of 20 litres ranged from R800 (\$43.35) to R1,500 (\$81.28) during mopane worm season. However, during the off-season when the demand for mopane worms is higher, the same bucket of 20 litres is sold at a price of R1,600 to R1,800 (\$86.70 to \$97.53). When asked about how much they make per season, the majority of respondents in Nsavulani village reported making between R2,100 (\$113.79) and R3,000 (\$162.55) whereas the majority of respondents in Muyexe village indicated that they make between R1,000 (\$54.18) and R2,000 (108.37) per season (Fig. 6). Some respondents indicated that they make more than R7,000 (\$379.29) a season.

A variety of reasons were given as to why respondents had decided to start selling mopane worms (Table 3), with majority of the traders in both Muyexe (47%) and Nsavulani (59%) seeing it as an opportunity to make an income, as



**Figure 5.** Quantity of mopane worms harvested per season in Muyexe and Nsavulani villages.



**Figure 6.** Net income per mopane season in MUYEXE and NSAVULANI villages.

**Table 3.** Reasons for entering mopane worm trade in MUYEXE and NSAVULANI villages.

Reasons for entering mopane worms trade	Muyexe (n = 79) %	Nsavulani (n = 58) %
Observed others doing it and decided to try it out	4	2
Combination of suffering and observed others	3	3
Suffering and hunger	9	7
For money, as had no income in household	47	59
Extra income	35	29
Retrenchment	3	0

they did not have any income in the household. Thus, the majority of community members in both villages are increasingly relying on self-employment with the mopane worm trade providing one such opportunity.

Other traders in MUYEXE (35%) and NSAVULANI (29%), particularly those who have jobs, spoke about making extra income to supplement their salaries. Few respondents in both villages indicated that they entered the mopane worm trade because of suffering and hunger, job losses, and observing others selling mopane worms and decided to try it out. Approximately 59% of respondents in MUYEXE village had been selling mopane worms for 0 to 10 years, 11% for 11 to 20 years, and the remaining 29% for > 20 years ( $X^2 = 28$ , d.f. = 2,  $P < 0.05$ ). In NSAVULANI village, 24% of respondents had been selling mopane worms for 0–10 years, 24% for 11–20 years, and the remaining 52% for > 20 years ( $X^2 = 8.83$ , d.f. = 2,  $P = 0.01$ ).

#### 4.6. Livelihood benefits from selling mopane worms

This study found that most of the people who are unemployed in MUYEXE (66%) and NSAVULANI (71%) villages are involved in the mopane worm trade. This is because the impoverished and jobless people did not have other sources of income, which makes them appreciate the mopane worm trade more. The unemployed respondents in both villages confessed that life would be impossible without the income generated from selling mopane worms. Thus, the mopane worm trade offers a safety net or survival strategy for the poorest members of

society. Respondents perceive this to be significant in minimising the unemployment rate, which is a serious problem in South Africa. Although the income from the sales of mopane worms was demonstrated by respondents to be very seasonal and short term, they reported that the income comes at a critical time in the household calendar. The income generated from selling mopane worms, particularly in January and February, was primarily used to cover school expenses. Thus, income earned comes at a critical point in the household calendar when money is required to pay school fees and buy school uniforms and books.

Other respondents in Muyexe (26%) and Nsavulani (35%) villages indicated that the money made from the sale of mopane worms was also used to buy household food, thus helping to alleviate poverty and improve livelihoods. A further 38% of respondents in Muyexe and 29% in Nsavulani stated that the money they made from selling mopane worms helped them with their cash flow problems since most households are broken at the start of the year following the festive season or December Holidays. 35% of respondents in Muyexe village and 29% in Nsavulani village, particularly those who are employed or self-employed, indicated that selling of mopane worms was important in diversifying livelihood options. They perceive diversifying sources of livelihoods as important in a world where food, clothing and services are expensive. Mopane worm sales were identified as an important opportunity in diversifying livelihood options because it was “easy to get into” as it did not require transport or buying of any goods or materials.

## 5. Discussion

This study found that the high rate of unemployment remained the major problem affecting both Muyexe and Nsavulani villages. Consequently, the majority of community members are increasingly relying on self-employment with natural product trade providing one such opportunity (Shackleton 2004; Shackleton et al. 2008; Wynberg et al. 2015; Sinthumule and Mzamani 2019; Sinthumule 2025). In these villages, besides livelihood benefits, most inhabitants derive nutritional benefits such as protein and mineral contents from harvesting mopane worms from the mopane trees that dominate the landscape around the two villages. Harvesting of mopane caterpillars in the study area is done mostly in the morning, which is like the findings of the case study done in Gwanda District in Zimbabwe (Manditsera et al. 2022). As reported by Thomas (2013), this study also found that the worms are collected by hand both from the mopane trees and on the ground where they drop. The majority of the respondents in both villages transport their worms by carrying them balanced in a container on their heads (and only a few harvesters rely on wheelbarrows and cars). Those who hire a car indicated that they pay the owner of the car 2 kg (degutted) of mopane worms per trip.

As in Botswana (Lucas 2010), Zimbabwe (Manditsera et al. 2022) and Namibia (Thomas 2013), processing of mopane worms was found to be labour-intensive as most mopane worms must be degutted to remove the undigested material (including faeces) by squeezing the worm between the thumb and fingers. However, unlike in Zimbabwe (Kozanayi and Frost 2002; Stack et al. 2003; Gondo et al. 2010; Manditsera et al. 2022) and Namibia (Thomas 2013), where mopane worms are roasted in hot ambers after degutting, in the study area,

this stage is not practiced. Mopane worms are only boiled in salty water after which they are dried in the sun for two or three days, depending on the weather conditions. Although traditionally, the collection and processing of mopane worms was limited to women and children (Kozanayi and Frost 2002; Stack et al. 2003; Makhado et al. 2009), in the study area the harvesting and processing of mopane worms is no longer limited to a specific gender, class, or age. Rather, a wide cross-section of households and community members carry out harvesting and processing. Unemployed males and youth are increasingly involved in harvesting of mopane worms as in the case of Namibia (Thomas 2013). Those who are employed are also involved in harvesting mopane worms. This study has also found that mopane worms are harvested both for consumption and trade, corroborating the findings of Thomas (2013) and Manditsera et al. (2022). However, the literature suggests that over recent decades, there has been an increased commercial harvesting of mopane worms in southern Africa (Hobane 1994, 1995; Mpuchane et al. 2000; Kozanayi and Frost 2002; Stack et al. 2003; Mogomotsi et al. 2018). As Lucas (2010) has noted, the shift from subsistence to commercial use has resulted from increased demand owing to changing diets and increased economic pressures in urban centres. Although a whole range of people are involved in the trade of mopane worms, this study found that the rural poor who are also unemployed were the ones who were mostly involved in the mopane worm trade. This offers short-term employment, which not only helps to alleviate poverty but also improves the livelihoods of traders. Eradication of poverty and hunger are key SDGs adopted by the United Nations General Assembly in January 2016. To achieve SDG 1 (no poverty) and 2 (zero hunger) by 2030, trading of mopane worms (insects) is a promising endeavour in developing countries, as they are a critical source of food. These results corroborate the findings of Thomas (2013) and Makhado et al. (2009).

This study found that mopane worms are sold in bulk from the supplier or harvester to regular customers who are mostly sellers in towns in the Mopani District. Harvesters in the study area tend to sell mopane worms in large quantities (of approximately 20 litres). This is because there are no local markets in the local rural areas because each household harvests its own mopane worms. In contrast, in Namibia (Thomas 2013) and Botswana (Mogomotsi et al. 2018), harvesters can sell mopane worms per mug or small container. Although the price is negotiable, a bucket of 20 litres ranges from R800 (\$43.35) to R1,500 (\$81.28). As in Botswana (Mogomotsi et al. 2018), harvesters from the Mopani villages studied hardly participate in secondary mopane worm markets (especially those in urban areas). Rather, they sell mopane worms based in their villages and the customers travel to them from urban areas. As Hope et al. (2009) have noted, rural–urban value-chain analysis indicates that consumers in urban areas will then pay four to five times the price that is received by a rural harvester. This is also in line with Makhado et al. (2014) who observed that mopane worms are more expensive in urban areas than in rural areas.

This study also found that some harvesters store their mopane worms so that they can sell them during the off-season when demand and prices are higher. During the off-season, the same 20-liters bucket is sold at a price of R1,600 to R1,800 (\$86.70 to \$97.53). Similar results were also found by Odongo et al. (2018) and Manditsera et al. (2022) in Zimbabwe. In Botswana (Mogomotsi et al. 2018), Namibia (Thomas 2013) and Zimbabwe (Kozanayi and Frost 2002;

Stack et al. 2003) some traders prefer bartering, whereas in the study area, respondents indicated that they prefer cash. The study found that in Nsavulani village, the majority of harvesters make between R2,100 (\$113.79) and R3,000 (\$162.55), whereas the majority of respondents in Muyexe village make between R1,000 (\$54.18) and R2,000 (108.37) per season. As in the study area, the income generated through mopane worm trade helps to buy groceries, pay school fees (Stack et al. 2003), alleviate poverty (Baiyegunhi and Oppong 2016) and improve the lives and livelihoods of people (Thomas 2013; Mogomotsi et al. 2018; Togarepi 2020). Although commercialisation has improved the lives and livelihoods of people, unfortunately, it has also led to the over-exploitation of mopane worms (Stack et al. 2003; Gondo et al. 2010; Thomas 2013) and unsustainable harvesting which involves the destruction of trees to speed up the collection (Stack et al. 2003; Akpalu et al. 2009; Lucas 2010). In the study area, there is perception among respondents that mopane trees are also apparently destroyed particularly for firewood collection and infrastructural development. This corroborates the results of Makhado et al. (2014) and Illgner and Nel (2000) who reported the collection of branches and trunks for firewood and construction purposes to be threats to mopane woodlands. These common practices, particularly in communal lands (Sekonya et al. 2020), have led to a decline in the abundance of mopane woodland which is also contributing to the decline in the abundance of the mopane worm. Although respondents did not mention decline in mopane worms in the study area, there might be a potential risk of decline based on the reported deforestation to pave way for development and for wood usage as a fuel. This might have long term implications on the availability of mopane worms in the study area.

## 6. Conclusion

This study set in Mopani District aimed to document the process involved in the commercialisation of mopane worms from raw material harvesting into a commodity that is sold to generate cash income. The study also sets out to assess the local importance of the mopane worm trade for households' livelihoods and poverty alleviation. The process of commercialisation of mopane worm starts with labour-intensive harvesting and processing; the harvesting is unmechanised (with no technology used in the processing of mopane worms). Although mopane worms were traditionally harvested for subsistence purposes, they are increasingly harvested for commercial purposes. Thus, mopane worms are increasingly traded in formal and informal markets to generate income. This study has demonstrated that the sale of mopane worm provides an important source of income for the majority of communities in both Muyexe and Nsavulani villages. Although the income earned from the sale of mopane worms is seasonal, nonetheless, it is appreciated by the households as attested to by the respondents.

In addition, even though the money earned by harvesting and conducting local trade in mopane worms is insufficient to meet household needs, it is critical in overcoming shortfalls in income. Trade provides cash at crucial times in the household calendar, thereby assisting households to cope with unusual expenses (such as paying school fees and buying school uniforms), offering a safety net or survival strategy for the communities, and diversifying livelihood

options. Thus, much of the value of earning from mopane worms lies in the timing (rather than the magnitude) of the income. Trade of mopane worms also plays a significant role to the majority of poor and unemployed whose households only depend on mopane worms as a source of livelihoods. Mopane worm trade thus plays a critical role in alleviating poverty and improving the lives and livelihoods of those involved in business.

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## Additional information

### Conflict of interest

No conflict of interest was declared.

### Ethical statement

This study was approved by the Faculty of Science Ethics Committee of the University of Johannesburg and an ethical clearance certificate was issued before the research proceeded (Ethics Reference Number: 2022-11-18/Sinthumule).

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### Author contributions

The author solely contributed to this work.

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### Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.