

## **Linking Knowledge and Practice: Assessing Options for Sustainable Use of Mopane Worms (*Imbrasia Belina*) In Southern Zimbabwe**

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### **ABSTRACT**

In recent years, there has been growing interest in the role of mopane worm utilization in the livelihoods of rural poor people and in the potential for expanding returns. Unfortunately, the resulting increase in the commercialization of the resource has led to its over exploitation. The paper assesses options for sustainable use of the mopane worm. Empirical data has been drawn from research carried out between April and July 2002 in several communities in Southern Zimbabwe where households harvest mopane worms. The data collection exercise utilized formal questionnaires and Participatory Learning Approaches. The sustainable use of mopane worms requires approaches that strive to strike a balance between conservation and improvements in the well being of the resource users. Such approaches should be grounded in knowledge gained from local experiences with local communities taking the pivotal stage. Options for enhancing livelihoods from mopane worms are varied. These include strategies associated with improving product quality, fetching better markets, and delaying the supply of the stock to the market. Sustainability can be achieved by promoting best practices that strive to maintain sufficient number of fifth-instar mopane worms, safeguard the host tree against exploitation, and to preserve the pupae.

**Keywords:** Options, sustainable use, livelihoods, mopane worm, value addition

### **INTRODUCTION**

In recent years, there has been a growing interest in the roles of non-timber forest products (NTFPs) in the livelihoods of poor rural people and in the potential for expanding returns to NTFP activities. The widespread utilization of NTFP, including the mopane worm in sub-Saharan Africa, has been confirmed by several studies (Cavendish, 1997). The increased commercialization of the mopane worm trade in southern Africa has led to over harvesting with collectors now collecting substantially more than a single person would have traditionally harvested for a family (Rebe, 1999). In South Africa, alone, overharvesting has led to a strong demand for imported mopane worms from Botswana Moruakgomo, 1996; Letsie, 1996. In addition to this challenge, there is also a severe lack in basic knowledge needed to manage the resource.

Current initiatives to expand these returns have largely remained biased towards seeking technical and institutional innovations in the management and utilization of such forest resources. Empirical data from other studies (Campbell., Luckert., Mandondo., Matose., & Nemarundwe.,2001; Campbell., Luckert., Mandondo., Matose., & Nemarundwe., 2002;

Nemarundwe and Kozanayi, 2001) show that natural resource management in semi-arid landscapes of southern Zimbabwe is primarily about local people, the users of resources themselves, far more than it is about prescriptive technical interventions from outside. Resource management interventions, therefore, need to be grounded on people's own knowledge systems, social and production objectives, and constraints (He, Zhou, Weyerhaeuser, & Xu, 2009; Pei, Zhang & Huai, 2009).

Exclusionary approaches to the management of NTFPs often resulted in conflicts and unsuccessful conservation of resources as local people continued to access them illegally (Pimbert and Pretty, 1995). In the last two decades, however, forest management approaches in developing countries have been characterized by a desire to combine both conservation and improvement of well-being of the communities living at the forest margins. In these new approaches, the participation of local communities in the management process is seen as crucial for striking a balance between conservation and improvements in human lives and key for sustainable management of resources (Wilshusen., Brechin., Fortwangler., & West., 2002; Borinni-Feyeraband, 1996). Ironically, many such new initiatives have not yet resulted in sustainable utilization of NTFPs and neither have they resulted in the improvement of the lives of the forest dependent people (Newmark and Hough, 2000, Marshall., Newton., & Schreckenber., 2003; Belcher & Schreckenber., 2007; Newton, 2008; Strandby Andersen., Prado Cordovia., Nielsen, Smith Olsen., Marten Sorensen & Kollman., 2008; Jensen & Meilby, 2008; Gubbi & Macmillan, 2008). This has fuelled debates on the utility of greater local involvement in management between conservationists and proponents of people-centered approaches. The former are calling for 'stricter enforcement protection' while the later consider this proposal as a 're-invention of the square wheel' and call for alternative people-centered approaches to be sought (Wilshusen et al, 2002, Borinni-Feyeraband, 1996).

In the absence of such newer approaches, it can be maintained that by simultaneously increasing cash income to rural communities and increasing value of forest and tree resources, commercialization of NTFP is arguably a means to both forest conservation and livelihood improvement (Jensen and Meilby, 2008; Avoce`vou-Ayisso.,Sinsin., Ade`gbidi., Dossou &Van Damme., 2009). Such thinking is backed by a market based approach to the use of NTFPs. In this approach, it has been argued that improved producer prices, adding value locally to NTFPs, and organizing people to manage the resources on their own may lead to sustainable utilization and, ultimately, to long-term economic rights of people to access NTFPs and commercialization (Homma, 1992; Stiles, 1994; Ndangalasi, 2007).

This paper focuses on the development of resource management frameworks for sustainable use of mopane worms that incorporates both conservation and livelihood objectives of mopane worm resource users. Such management frameworks are grounded on research generated data in which technical, scientific knowledge, and local knowledge over resource use are indispensable. The analysis suggests different sustainable options available to mopane worm producers across southern Zimbabwe.

This paper is structured into five sections. Following this introduction, we describe the principal features of the mopane worm biological life in the mopane belt across southern Zimbabwe. Section 3 then introduces an overview of the socio-economics of the mopane worm. This will, then, permit an assessment of various options for enhancing earnings from

mopane worms. Section 4 identifies various strategies that mopane producers can employ if mopane worms are to be harvested sustainably. Tips on how best to regulate the mopane worm harvesting industry are also presented here. This analysis will then allow us to investigate the potential for different types of technical and institutional innovations (here referred to as sustainable options for mopane worm use) in the sustainable use of mopane worms.

### **What are ‘Mopane Worms?’**

Mopane worms (*amacimbi* in Ndebele; *madora* in Shona) are the late- instar caterpillars of the mopane moth (scientific name *Imbrasia belina*, Figure 1). This moth is widespread across the warmer parts of southern Africa, but is particularly common in areas where the mopane tree, *Colophospermum mopane* (*amaphane* in Ndebele, *mupani* in Shona) is abundant, especially in southern Zimbabwe, northern South Africa, Botswana, Namibia, and southern Angola.



Fig 1: The mopane worm (*Imbrasia Belina*)

*Source: Picture taken in one of the study sites by Peter Frost*

In Zimbabwe, mopane woodland occurs in an arc of country, stretching from Tsholotsho in the northwest, through Plumtree, Mangwe, Matobo, Gwanda, and Beitbridge in the west and south, to Mwenezi, Chiredzi, and the lower Save Valley in the east. Within this area, mopane moths have two generations a year, in October-November and February-March, with the larvae often occurring in large numbers a month later. Mopane trees and the moths are also present in the Zambezi valley, but they are not as widespread there as in southern Zimbabwe

### **What is the life cycle of the mopane moth?**

Across most of their range, adult mopane moths emerge in October-November and again in February-March. The adults do not feed. They live for only a few days, during which period the males locate females by following chemical attractants (pheromones) released by the females. The adult moths do not disperse far from where they emerge. After mating, a female lays a single cluster of 50-200 eggs around twigs or on the leaves of host plants. The eggs hatch about 10 days to produce tiny black larvae (caterpillars). During their growth, these larvae pass through five growth stages, each usually lasting 5-7 days. Each larval growth stage is referred to as an in-star (instar I being the earliest growth stage and instar V being the last). Overall, the larvae grow for about 4-6 weeks, during which time their body mass increases 4,000 times. It is this massive increase in size that necessitates regular molting of their outer skin or the exoskeleton as the larvae pass from one instar stage to another. During instar stages I-III, the caterpillars cluster together in groups of 20-200 individuals, feeding on the leaves of their host plants. Following the molt into instar stage IV, these groups break up and disperse. The caterpillars in these later instar stages (IV and V) are called 'mopane worms'. During some years, the host trees may contain millions of caterpillars, occasions that are referred to as 'outbreaks'. This is when 'mopane worms' are collected and eaten by people in large numbers.

At the end of the larval stages, the fifth instar caterpillars (*insumbe* in Ndebele) burrow into the soil near the base of mopane trees and transform themselves (metamorphose) into pupae. These first- generation pupae generally develop rapidly into a second generation of adult moths, which emerges in February-March, about one-and a-half months after pupation. The female moths soon lay eggs which develop into a second generation of caterpillars. By April, those that have survived to the final instar stage (Instar V) burrow into the soil to form a second generation of pupae. These undergo a period of diapause (dormancy), before emerging 6-7 months later at the start of the next rainy season. The numbers of mopane worms present during these two periods of emergence vary greatly from year to year, apparently due to the weather and the presence of parasites of the early instar larvae. In general, the numbers present during the second outbreak (March-April) are less than those occurring during December-January.

### **MATERIALS AND METHODS**

Linking knowledge and action requires the existence of an extensive pool of knowledge that cut across a representative sample of mopane worm producers in Southern Zimbabwe. Options for sustainable use of the mopane worms presented here have been informed by a cross section of surveys and case studies from a variety of communities across southern Zimbabwe. It is not the purpose of this paper to review findings from these studies, but to explore common themes that will provide valuable information on the sustainable use of the mopane worm.

Common insights here have largely been drawn from research we carried out between April and July 2002 in several communities in Southern Zimbabwe where households harvest mopane worms. Formal questionnaires, with randomly selected households, were used together with key informant interviews, focus groups discussions, and observations. Key mopane worm data variables relating to the socio-demographics of households and involvement in mopane worm activities (harvesting, processing, consumption, and marketing) were collected. Formal survey data is also complimented with

qualitative data from participatory livelihood analysis (PLA), undertaken in Gwanda, Chiredzi, and Mwenezi (SAFIRE, 2002). In addition, a series of feedback workshops were carried out in Bulilil Mangwe, Matobo, Gwanda, Chiredzi, and Mwenezi, where a number of issues pertaining to the sustainable use of mopane worms were presented to communities and reviewed.

Figure 2 shows the location of five districts in Zimbabwe, for which detailed survey results and/or PLA data are available. These mopane worm producing regions lie in areas that are classified as poor (Figure 3).

**Why are mopane worms important?**

When mopane occur in large numbers, they are collected by people, cleaned, dried, or roasted, and either kept for consumption, or more commonly nowadays, sold or bartered. Data collected from southern Zimbabwe show that most households harvest mopane worms when outbreaks occur and that 79-95% of

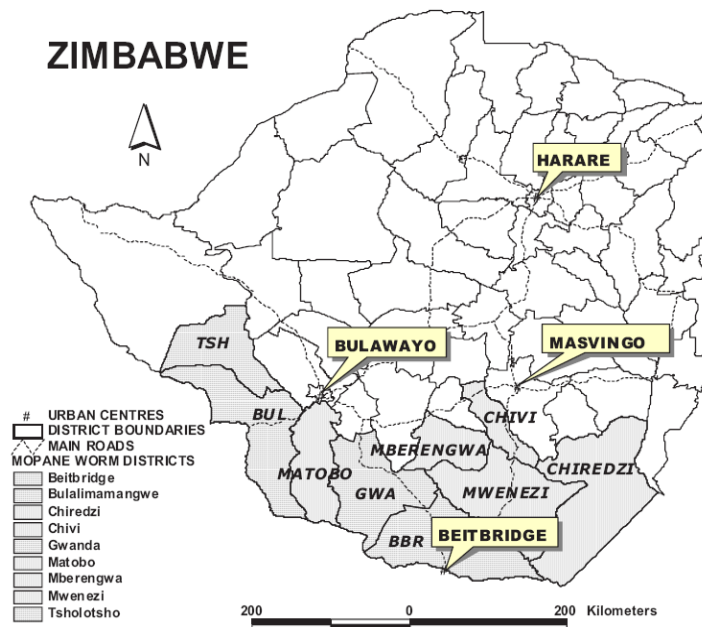


Figure 2: Location of study sites

Source: Stack et al, 2003

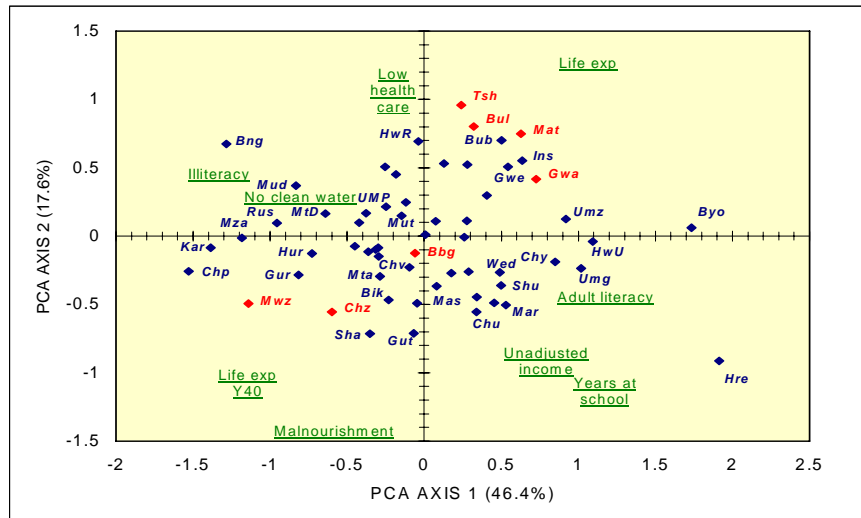


Figure 3. Principal Components Analysis of 60 districts in Zimbabwe in terms of nine indicators of human poverty and development, using data given in the 1998 UNDP Human Development Report for Zimbabwe (as amended in 1999), but based data collected in the mid 1990s. The seven districts in which mopane worm harvesting is widespread are shown in red. They are Gwanda (Gwa), Matobo (Mat), Tsholotsho (Tsh), Bulilimamangwe (Bul), Beitbridge (Bbg), Chiredzi (Chi), and Mwenezi (Mwe).

Source: Gondo and Frost, 2002

these households will then sell at least some of what they have collected or exchange them for other goods (Figure 4).

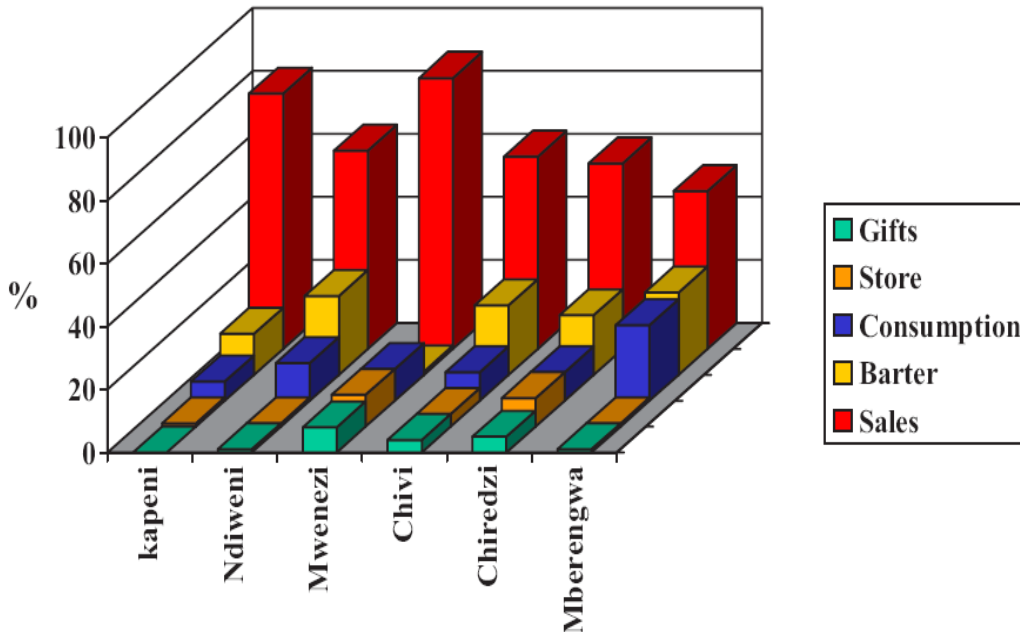


Figure 4: Utilization of mopane worms by study area

Source: Stack et al, 2003

Money obtained from the sale of mopane worms is important both to rural producers (Table 1), who harvest the caterpillars in the wild, and to urban traders, who buy mopane worms from rural producers or other traders and sell them eventually to consumers.

Table 1. Use of income from Mopane sales, Zimbabwe study areas, 2002

Income Use	Masvingo						Midlands	
	Mwenezi N=45		Gwerima N=42		Chilonga N=30		Bangwe? N=31	
	% hhld	% 1st	% hhld	% 1st	% hhld	% 1st	% hhld	% 1 <sup>st</sup>
Buy food grains	82	40	90	35	53	na	36	16
Buy other food	84	36	93	39	67	na	68	28
Buy agric Inputs	73	11	73	12	60	na	48	16
Buy agric implements	36	7	39	7	3	na	na	na
Buy cattle	7	0	7	0	0	na	na	na
Buy goats	22	2	24	0	3	na	na	na
Medical expenses	71	2	78	2	na	na	32	0
Funeral expenses	Na	Na	na	Na	0	na	68	0
School fees/stationary	78	38	85	41	60	na	48	12
Travel	73	4	81	5	40	na	12	0
Buy clothes	71	11	78	2	23	na	88	36
Buy household utensils	80	64	88	70	Na	na	56	12
Buy durables	na	na	na	na	3	na	68	

**Note:** 1<sup>st</sup> means the share of households who indicated that income from MW sales was the main source of cash for this expenditure. For example, 82% households in Mwenezi used income from MW sales to purchase food grains, and 40% of households indicated that this income source was the most important source of income for purchasing food grains.

On average, consumers pay 4-5 times more than the prices received by producers, depending on whether or not the mopane worms have been prepared before hand as a snack or meal. Some mopane worms harvested in Zimbabwe are even traded in neighboring countries or further afield (*e.g.* in South Africa, Botswana, Zambia, and the Democratic Republic of the Congo). The total value of this trade is not known precisely, but has been estimated to be worth many millions of United States dollars.

For rural households in southern Zimbabwe, the annual harvest of mopane worms may contribute up to a quarter of a household's cash income, depending on the quantity of mopane worms harvested, the proportion that is sold, and the

household's other sources of income. Mopane worms can, therefore, contribute to improving rural people's livelihoods in various ways, including:

- Supplementing seasonal shortages in cash or food (the mopane worm outbreaks in December/January occur at a time when rural families are short of both food and cash);
- Buffering families against unexpected shortages in food or income caused by drought, illness, or some other sudden events;
- Supplementing expenditure on important things, like education, food, health, clothing, household utensils, agricultural tools, improved shelter, travel, and social functions; and
- Providing cash for investment in various productive enterprises, such as buying additional mopane worm stocks or other stocks or other commodities for trading, purchasing agricultural inputs (including livestock), engaging in non-farm enterprises, or building household assets generally so as to improve the family's capacity to expand future agricultural production or other business activities.

#### **How do prices for mopane worms in towns and cities differ from those in rural areas?**

Prices of mopane worms have increased sharply in recent years, largely reflecting the decline in value of Zimbabwe dollar and the corresponding rise in the costs of goods and services, including transport to and from rural areas. Consequently, we only consider the price differences in general terms. On average, over the three years, 2001-2004, prices received by rural producers were 26-87% of those being paid to traders in the cities, depending on the buyers (urban traders- 83-87%, bulk buyers- 42-71%, and city markets- 26-50%). The differences in price do not represent the traders' profits, as the costs of doing business (labor, transport, rents, licenses, the cost of money, etc.) have not been taken into account. Although rural producers would receive more per 20-liter bucket by selling their stock in town, whether they would make more overall would depend on how much they sold and the price they received, minus the costs of going to town, transporting their mopane worm stocks, staying in town (if they had to remain overnight to sell their stocks), and taking into account the value of their time (they could have been doing other productive things instead) or any other costs that they might have incurred on the way. Producers can reduce the unit costs of selling mopane worms by forming marketing groups in which only one or two people go to town with the accumulated stock of the whole group to sell on their behalf. Everyone in the group would then get paid according to the quantity of mopane worms they produced minus their share of transport and marketing costs.

#### **How can those who harvest and process mopane worms get more money for their product?**

Value addition can be done at various stages of the mopane worm marketing chain (figure 5). There are quite number options available to mopane worm producers in relation to enhancing their earnings from their mopane worm produce.



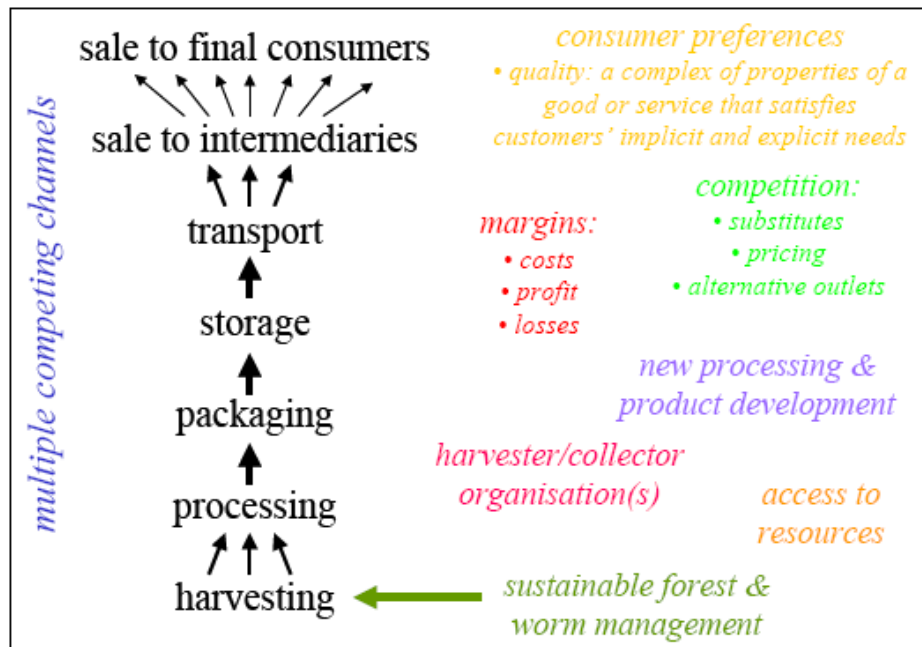


Figure 5: The marketing chain and indicators for value addition

Source: Frost and Kozanayi, 2002

Value can be added to a product in a number of ways. First, the quality of the product can be improved. Those who harvest mopane worms do this by drying, roasting, and sometimes adding salt to the worms. By increasing the shelf life of the worm, these measures ensure that the quality of the mopane worm produced is preserved. Ensuring that the mopane worms are not contaminated with microorganisms that can make people ill is also an important step. Research at the University of Zimbabwe has shown that the level of contamination increases along the trading chain from producers to consumers, suggesting poor hygiene by some of those who handle mopane worms. Microbial assays of mopane worms on sale in South Africa by J. Ramalivhana (University of the North) have also shown substantial contamination by among others, *Enterobacter* spp., fecal *Escheridia coli*, various fungi, including some producing aflatoxins (SAMRA News, 2002, D Wessels, 2002). A public education program on the need for better hygiene among those handling mopane worms at all stages of the production process, together with development of low-cost technologies to improve de-gutting and subsequent processing are needed.

Some people add further value by packaging mopane worms, or by cooking or spicing them before they are sold to consumers as snacks. This strategy can be referred to as 'the change of form strategy.' Some companies (like Cairnes food in Mutare) used to sell canned mopane worms, but low sales of more expensive product failed to offset the higher production costs.

Secondly, value can be added by concentrating and transporting mopane worms from the production areas to places where consumers will buy them. We call this 'the change of location strategy'. People who harvest mopane worms play a vital role here by gathering the worms initially into saleable quantities. But rural traders are also important because they further

concentrate these stocks and transport them to the major markets, from where other traders disperse them to the final points of sale. There are labor and transport costs associated with each stage, particularly in conveying stocks from rural to urban areas. These costs are one main reason for the increase in price along the marketing chain.

Thirdly, value can be added by making mopane worms available to consumers at times of high demand and low supply. This is done by storing mopane worms when there is excess in the markets, such as during and just after the main outbreak periods, and releasing them later when demand is still high but supply is low. Some rural producers do this, but bulk traders in towns and cities more often do this

**What are the advantages and disadvantages of storing mopane worms for sale at a later date?**

Prices paid for mopane worms are generally lowest when there are large amounts available for sale in the markets; that is, during December/January and April/May. Prices rise in the following months, especially from May onwards, as fewer mopane worms are available then for sale. Data from southern Zimbabwe show that in some years, prices can be up to four times higher at the end of a season than at the beginning (Figure 6).

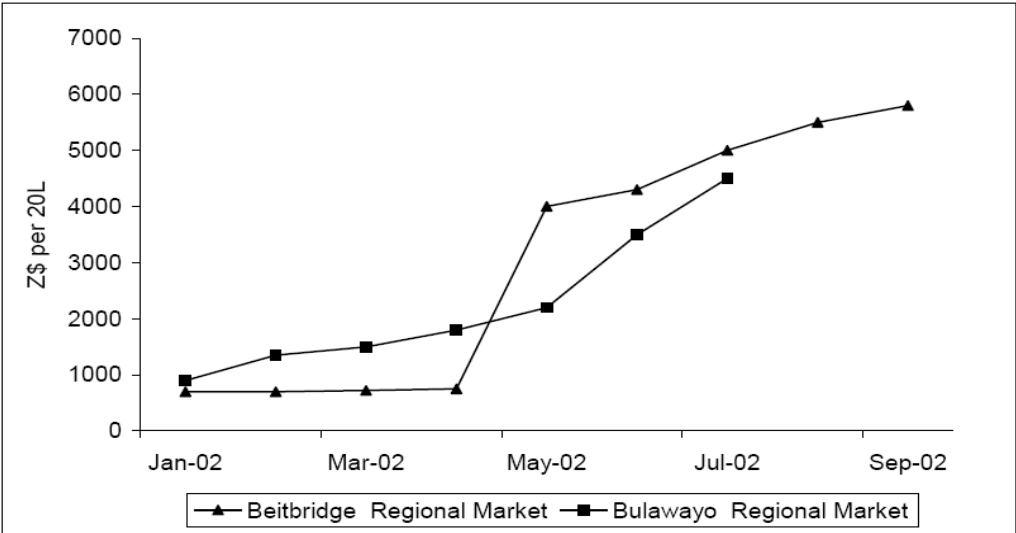


Figure 6: Trends in mopane worm prices January to September, 2002 (nominal prices)

Source Frost and Kozanayi, 2002

People can potentially benefit from this rise in price if the cost of storage is less than the additional money earned by selling when prices are higher. It is important however to note the quality of the mopane worm stock tends to deteriorates (eventually), particularly if they are not kept completely dry or if they become infested with beetles. Such spoiled stocks may fetch a much lower price or may even become unsalable. Choosing when to sell, and at what price (always assuming that a buyer can be found at that price), requires in-depth knowledge in trends of market prices, the increasing costs of storage, and what opportunities are being given up by storing the mopane worms rather than selling them early and using the cash for a more productive activity. It is, therefore, only advantageous to store mopane worms for sale at a later date if one can realistically expect a rise in real prices-that is, taking inflation into account-and if this expected price rise will be more than

the costs of storage. Empirical data from some communities have shown that a rise in the price of mopane worms does not necessarily translate into better returns. The quantities of mopane worms sold per household and the income derived from these sales in two communities in Matobo district are given in Table 2. Despite presumed variations in production from year to year, the average quantity of mopane worms sold per households appears to be increasing over time. In nominal terms, the mean income per household from the sale of mopane worms has also risen, as has the average price paid for mopane worms.

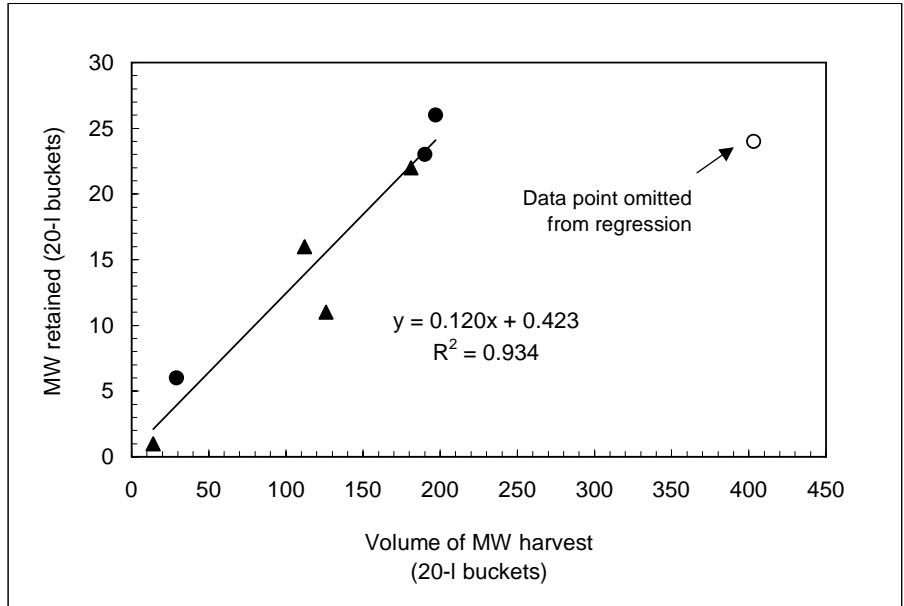
Gross income per household in the 2001/02 harvesting season averaged Z \$5,506 in Kapeni village and Z \$3,554 in Ndiweni. These increases, however, largely reflect the effect of inflation on the value of the currency rather than any intrinsic increase in the value of mopane worms. When prices and income are standardized to a 1998/99 base, using the all-items Consumer Price Index as an adjuster, the average price received by sellers of mopane worms in the two villages over the past four years has declined by 40-48% in real terms over the past 4 years (Table 2). As the sellers are probably price-takers, they are generally not able to hold out for a higher real price from buyers.

Table 2. Average quantities of mopane worms sold or bartered by households in two villages over four years and the corresponding income received. Data for the period 1998/99-2000/01 from Gondo (2001). The quantities in kg sold or exchanged have been converted from the original units of sale – 20-litre buckets – using a conversion factor of 5.7 kg per bucket.

	<u>Kapeni</u>				<u>Ndiweni</u>			
	1998/99	1999/00	2000/01	2001/02	1998/99	1999/00	2000/01	2001/02
Mass of mopane worms sold per household (kg)	32.0	28.5	19.0	53.1	19.3	29.9	34.2	37.9
Average price (nominal Z\$ kg <sup>-1</sup> )	32.6	37.2	28.1	103.7	34.1	41.5	87.7	93.8
Mean income per household (nominal Z\$)	1042	1060	534	5,506	658	1,242	2,999	3,554
Average price (real Z\$ kg <sup>-1</sup> )	32.6	23.8	11.5	19.5	34.1	26.6	35.8	17.6
Mean income per household (real Z\$) <sup>1</sup>	1042	678	219	1,035	658	796	1,224	667
Number of households selling mopane worms	23	26	6	35	13	16	1	17
(% of all households)	(74)	(84)	(19)	(100)	(77)	(94)	(6)	(68)

<sup>1</sup> The value of the Zimbabwe dollar standardised to a January 1999 base using the annual change in the Consumer Price Index over subsequent years.

Instead, they appear to be compensating by harvesting more intensively and selling more. One precondition for storing mopnae worms for later sales is having a good harvest. If supplies are good, then the household can afford to retain some for future sales (figure 7).



**Figure7.** Relationship between the size of the annual harvest of mopane worms in Kapeni (closed and open circles) and Ndiweni (triangles) and the quantity retained for household consumption.(Data for 1998/99 to 2001/02 One point was omitted from the regression. The relationship is statistically significant at  $p < 0.001$  ( $r = 0.966$ ,  $df = 4$ ).

Source: Gondo and Frost, 2002

The relationship between the annual harvest (X) and the amount of mopane worms retained for consumption (Y) over the past six years in Matobo district is estimated by the equation,  $Y = 0.0714X + 9.8207$  with  $r = 0.92$ ,  $p < 0.009$  and  $df = 4$ . Over the recorded years, there has generally been a positive relationship between the amount of mopane worms harvested and the quantities retained either for consumption or for sale. It, generally, follows that when supplies are good, then the households would be able to spare some for later sales.

#### How can we ensure that mopane worms are harvested sustainably?

Three things are important to manage if mopane moths are to survive in sufficient numbers to continue to produce periodic outbreaks of large numbers of mopane worms, and if the mopane worms themselves are to have the food plants on which to feed and grow.

- **Sufficient numbers of fifth instar mopane worms must survive harvesting to be able to pupate and produce the next generation of adult moths.** This means that people should not harvest all the larvae but leave some to pupate. Alternatively, the harvesters could decide not to harvest mopane worms from some woodland areas in a particular year, thereby allowing the larvae there to pupate. This option, however, requires a strong commitment from every

community member. It is likely to work where there strong local institutional arrangements in place to ensure compliance. Strengthening local institutional arrangements becomes a bigger challenge since empirical evidence from elsewhere is pointing towards their breakdown (Campbell *et al*, 2002). Setting of conservation priorities and defining sustainable harvest levels is likely to be difficult if not backed by any meaningful scientific data (Wickens, 1991; Zuidema, 2000). Additional scientific knowledge would therefore be required.

- ***The pupae should remain undisturbed.*** In some areas, people dig up and harvest the pupae, mainly during times of when food is in short supply. While this is understandable, it threatens the production of adults in the next generation and so should generally not be done.

For female moths to have relatively secure sites on which to lay eggs, and for the larvae to grow successfully once the egg hatch, **there must be a sufficient numbers of mopane trees**, the larvae's main food source. This means stopping practices that destroy mopane trees and woodlands. These include breaking trees and branches while collecting mopane worms, clearing large areas of mopane woodland for unproductive purposes, and allowing fires to burn out of control. Research carried out in South Africa has shown that mopane trees, or larger trees that are re-sprouting after being cut down, as much of the canopy, can be reached by goats. Large numbers of goats can therefore contribute to degrading mopane woodland-the habitat for mopane worms-unless browsing is controlled through, for example, better herding. Preserving the mopane tree also means managing the demand for its products. Rural households use a variety of products from the mopane tree (Table 3). One way to manage demand would be to explore options for using substitutes.

Table 3: Mopane tree uses by households in Kapeni and Ndiweni communities, Matobo district.

Household Use	Tree part used	Economic characteristics				Desired Mopane characteristics	Close purchasable substitutes
		Cons good	Prod Input	Asset	Sale		
Construction poles <sup>1</sup>	Timber			√	√	Hard; heavy; termite resistant	Bricks, concrete
Fence posts	Timber	√	√		√	Hard; heavy; termite resistant	Treated timber
Carvings <sup>2</sup>	Wood	√			√	Colour of wood, strength	Commercial items
Furniture <sup>3</sup>	Timber		√		√		Commercial items
Agricultural tools <sup>4</sup>	Wood	√	√		√	Colour, strength and pest resistant	Metal implements
Household utensils <sup>5</sup>	Wood	√	√		√	Strong but flexible wood	Metal and plastics
Firewood	Bark	√			√	Durability; does not split	Paraffin
Rope <sup>6</sup>	Bark	√			√	Long burn; smokeless; abundant	Commercial rope
Gum	Bark, Roots, Leaves	√	√	√	√	Easy to trip; rope multi-purpose	Commercial medicine
Medicine	Seeds		√		√	Free medicinal source	Commercial medicine
Resin <sup>7</sup>	Leaves	√			√	Open / unrestricted access	?
Leaf litter <sup>8</sup>	Leaves		√		√		Commercial fertilizer
Livestock browse	, Twigs				√		Grass
Edible caterpillars	Silk worm cocoon					Tasty when eaten	Meat, fish
Traditional dance clothing	shells					Abundant	Commercial items
						Available during dry season; has high nutritional value	
						High protein, tasty, ready market	
						Ideal for the purpose	

- 1 House walls, floors and roof beams, granaries, drying racks, livestock coops and pens
- 2 Walking stick, hunting stick
- 3 Doors, ladders
- 4 Skeys, hoe and axe handles
- 5 Pestles, mortars, cooking sticks
- 6 For tying firewood bundles, thatch on roofs, hut frames, baskets, herding whips
- 7 Seeds mostly eaten by school children during school break time
- 8 For green manure and home made floor polish

Empirical evidence from elsewhere has also revealed that despite the existence of a number of scientific innovations, the management of mopane woodlands by communities has hardly been influenced by research findings (Musvoto., Mapaure.,

Gondo., Ndeinoma., & Mujawo., 2007). Some of the findings, e.g. on tree thinning, coppicing, and tree die back (Tietema., Kgath., & Merkesdale., 1988; Smit, 2001) have potential for use by rural communities to effectively manage mopane woodlands. Pollarding, the cutting back of a tree's branches to the trunk, encourages the growth of new shoots and increases the leaf. This would obviously improve food reserves for the worm. Such scientific knowledge however needs to be judiciously blended with harvesters' own local circumstances if they are to be successful (Gondo., Musvoto & Mujawo., 2007; Musvoto *et al*, 2007; Gondo, 2008)

### **How can the harvesting of mopane worms be better regulated?**

One of the current problems many rural communities face is uncontrolled harvesting, especially by people who are not resident in the area. Whereas some of these people are relatives of those living in the area, others are outsiders. Communities need to decide how harvesting should be regulated, how these regulations can be enforced, and what penalties there might be for those who disregard the regulations. Rules should be established about who can have access to an area to collect mopane worms (and other natural resources), how much they can collect; and whether they should pay a levy to the community for the privilege. Such rules could also specify acceptable and unacceptable means of collecting mopane worms (for example, cutting down mopane trees or breaking branches to make it easier to collect mopane worms should be prohibited). Communities also need to decide how they would deal with offenders. Such rules would have more force if endorsed by the Rural District Council as by-laws.

Some RDCs already impose a levy on traders coming from outside the district to purchase mopane worms. In this regard, it is important that such levies do not deter traders, or cause them to pass on the costs to rural producers by paying them less. Ideally, the funds that are raised should be reinvested in activities that will support the productive, profitable, and sustainable use of mopane worms and mopane woodlands. This could be through better enforcement of local regulations governing the use of natural resources, improvements in local infrastructure (*e. g.* roads and local markets), and acquiring and providing accurate and timely information to producers on prevailing prices for mopane worms in urban markets, so that people can negotiate more effectively with traders over prices.

### **CONCLUSION**

Evidence of widespread utilization and exploitation of mopane worm resources across southern Africa is overwhelming. Our analysis in southern Zimbabwe reveals that research generated data is indispensable in mapping out sustainable options for the use of mopane worms and subsequently in resource management initiatives that strive to strike a balance between conservation and improvements in the wellbeing of the resource users.

Meeting conservation objectives would require proper harvesting practices that would ensure the survival of sufficient numbers of fifth instar mopane worms to facilitate pupation and guarantee produce for the next generation of adult moths. This means that people should not harvest all the larvae, but leave some to pupate. Secondly, the pupae should remain undisturbed. This requires that harvesters should not dig up and harvest the pupae, even during times when food is in short supply as this practice threatens the production of adults in the next generation. Such efforts, however, need to be

complemented by the proper management of the host tree as it provides the main food source for the mopane worm. This means desisting from bad practices that unnecessarily destroys the mopane woodlands. Setting of conservation priorities and defining sustainable harvest levels is likely to be difficult if not backed by any meaningful scientific data. The general paucity of such know among communities would mean that additional research is required. Technical innovations such as coppicing, pollarding, and thinning are likely ensure sound mopane woodland management only if they are grounded on resource users preferences and local circumstances. Empirical evidence from southern Zimbabwe reveals that some communities prefer certain technical innovations over others because of their varying local situations.

An effective regulatory frame work is also required to control the harvesting patterns of the mopane worms. Such initiatives need to be fostered at both local and the Rural Distict Council levels. At the lower resource governance levels, it is imperative that existing regulatory instruments be re-engineered so that the roles of the traditional leadership in resource management are strengthened.

Such conservation efforts would be futile if they are not matched with an improvement in the well being of resource users. Research data has revealed three basic ways in which mopane worm harvesters can increase their earnings from mopane worms.

One way would be to improve the quality of the product. This can be done by drying, roasting, and sometimes adding salt to the worms. By increasing the shelf life of the worm, these measures ensure that the quality of the mopane worm produce is preserved. Some people add further value by packaging mopane worms, or by cooking or spicing them before they are sold to consumers as snacks. We have defined this strategy as *'the change of form strategy.'* Secondly, value can be added by concentrating and transporting mopane worms from the production areas to places where consumers will buy them at a better price. We called this *'the change of location strategy.'* Thirdly, value can be added by making mopane worms available to consumers during times of high demand and low supply. This is done by storing mopane worms when there is excess in the markets, such as during and just after the main outbreak periods, and releasing them later when demand is still high but supply is low.

For such resource sustainability options to bear fruits, it is imperative that research generated scientific knowledge is judiciously blended with resource user preferences and local circumstances.

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