

**THE EVOLUTION AND IMPACTS OF MOPANE WORM
HARVESTING: PERCEPTIONS OF HARVESTERS IN
CENTRAL BOTSWANA**

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DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

(Signature of candidate)

_____ day of _____ 20_____

Abstract

The aim of this study was to investigate the evolution and impacts of mopane worm harvesting in central Botswana. Commercialisation of mopane worms has increased over the years and it is allegedly due to an ever-increasing demand both locally and regionally. Harvesters in some areas of southern Africa have employed new harvesting practices that quicken the harvesting process. Based on perceptions of the harvesters, the study assesses how harvesters in central Botswana have responded to the demand and how this response has impacted harvesting outputs. In order to assess motivations for harvesting, how harvesting trends have evolved over time and whether they have an impact on the mopane worms and their habitat, semi-structured interviews of harvesters were coupled with participant observations in the Tamasane-Kgagodi area, central Botswana. The survey was conducted during the harvesting season in December 2009. In contrast to previous studies this study revealed that harvesting methods have not changed significantly but that the number of mopane worms has declined due to climatic factors and over-harvesting due to a greater number of harvesters. People harvest mopane worms primarily for consumption and commercialisation purposes. The increasing number of harvesters is of concern and warrants active engagement of the government with rural communities to foster sustainable harvesting of mopane worms.

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ACRONYMS AND ABBREVIATIONS

FAO.....Food and Agricultural Organisation

MWs.....Mopane Worms

NTFP.....Non Timber Forest Product

UNDP.....United Nations Development Programme

1. Introduction

1.1 Background of the study

Botswana is endowed with very rich ecosystems and genetic diversity. Local communities depend on biodiversity, which offers multiple opportunities for development and improvement of human well-being (Botswana Biodiversity Strategy and Action Plan, 2007). Of Botswana's overall biodiversity, the mopane worm (*Gonimbrasia belina*) or *phane*, a Setswana vernacular name, is one of the most important species. With regard to the socio-economic well being of communities living in the northern and eastern parts of Botswana, it is first considered a vital traditional delicacy (Stack *et al.*, 2003). In addition, local rural communities rely on mopane worms as they have high protein content (Bartlett, 1996; Molose, 1997; Greyling and Potgieter, 2004; Illgner and Nel, 2000).

Mopane woodland occurs throughout southern Africa region and is prevalent in much of Botswana including the Central District where the study took place (Marias, 1996). Mopane worms feed on a number of tree species, but it is the Mopane tree (*Colophospermum mopane*) that is the most suitable in terms of the developmental stages of the worm (Teferra *et al.*, 1996; Moruakgomo, 1996; Stack *et al.*, 2003; Musvoto *et al.*, 2007). The worm's name comes from this association with the Mopane tree (Bartlett, 1996).

The harvest of mopane worms is common in Botswana. Every year there may be two harvests of mopane worms depending on the amount of rainfall received during that season (Illgner and Nel, 2000). The first harvest is between December and January while the second is between April and May (Mpuchane *et al.*, 2000; Hope *et al.*, 2009; Madibela *et al.*, 2009). The first outbreak of mopane worms occurs near the start of summer (December) when most households are in need of sustenance as well as cash for the festive season celebrations and for upcoming school fees (Toms and Thangwana, 2005). During the harvest period, people commute to the outbreak areas while others establish temporary informal shelters/campsites in the outbreak areas to harvest the

worms (Stack *et al.*, 2003).

Many generations in the mopane belt have always relied on mopane worms as the cheapest source of protein (DeFoliart, 1999). Previous studies highlight that the recent demand in southern Africa for mopane worms for different purposes (consumption, stock feed, commercial purposes) has resulted in many people from all social classes wanting to participate in the harvesting and trading processes of the worms (Stack *et al.*, 2003). In recent years Botswana experienced an increase in number of harvesters, especially men and youth, and this has led to harvesters establishing informal campsites at the outbreak areas instead of commuting, to speed up the process of collection. Cases of tree and branch breakages to quicken the harvesting process have also been observed in certain parts of southern Africa (Ditlhogo *et al.*, 1996; Athlpheng *et al.*, 1998; Menzel and D'Aluisio, 1998). It is thought that the evolution of traditional mopane worm harvesting is commercially-driven and has resulted in cases of overexploitation of the resource in certain parts of Botswana (Gullan *et al.*, 2005). This study therefore examines these claims through the experiences of harvesters in order to confirm or refute them, and to make appropriate recommendations.

1.2 Statement of the problem

This study investigates the evolution and impacts of mopane worm harvesting in central Botswana. The study is based on the perceptions of harvesters with the aim of answering these research questions:

1. How have the harvesting practices of mopane worms evolved in central Botswana?
2. What are the traditional and current motivations for harvesting mopane worms in central Botswana?
3. What are the perceptions of the harvesters regarding the impacts of the modern harvesting practices on mopane worms and mopane woodlands?

1.3 Purpose of the study

The purpose of the study was to fill gaps in knowledge on mopane worm harvesting practices and how they have changed over time. Studies on mopane worms have been carried out using multidisciplinary approaches that include botanical, nutritional, agricultural, biological, social, ecological and economic. Some of the studies covered by these approaches include: mopane worms and their habitat; mopane worms and value addition; ecology of mopane worms and woodlands; mopane worm utilization; commercialisation of mopane worms; and the most recent, mopane worm farming technology (Kozayani and Frost, 2002; Stack *et al.*, 2003; Rasengwatshe and Madibela, 2005). However, there was very little research on the evolution of the harvesting practices of mopane worms and on the perceptions of the harvesters themselves, hence this study.

1.4 Study Area

Botswana is a land-locked country centred in Sub-Saharan Africa. Like many countries in Africa, Botswana is reliant on natural resources such as mineral resources (diamonds), cattle-rearing and tourism to generate the national revenue (http://www.unbotswana.org.bw/about_b.html). Rural area dwellers that fall within the mopane woodland belt engage in diverse portfolio of farm and non-farm activities to sustain their livelihood. The harvesting of mopane worms is one of the common activities through which the rural households diversify their livelihood strategies. Studies reveal that a majority of the areas in which mopane worms occur in southern Africa (South Africa, Botswana, Zimbabwe and Namibia) lie in regions of low natural resource potential, where cultivation is risky and extensive livestock production is the most suitable form of agriculture (Stack *et al.*, 2003). Unreliable climate causes regular failure of staple grains and a high level of vulnerability to food insecurity, hence a reliance on forestry resource products such as mopane worms (Stack *et al.*, 2003).

The study was conducted in the Kgagodi-Tamasane area in the Central District of Botswana. Kgagodi and Tamasane are small villages about 18 km apart. Tamasane and Kgagodi villages are relatively small in terms of population sizes. Kgagodi has a population of 1 343 while Tamasane's is 1 012 (Botswana, 2001). Three informal settlements around the Tamasane-Kgagodi area were selected to conduct the survey. Two of the informal settlements were in Dikabeya cattle-post area while one was in Maope.

The Kgagodi-Tamasane area is one of the areas that experience the influx of mopane worm harvesters during the outbreak season (*Mmegi the Reporter*, 18 April 2008). Some of the harvesters travel long distances to harvest mopane worms in this area. This area lies in close proximity to Botswana's busiest road, the A1 Highway, which joins the only two cities in Botswana: Francistown and Gaborone. Kgagodi is about 39 km from this road while Tamasane is 21 km. A nearby town is Palapye, about 41 km from Tamasane and 59 km from Kgagodi village (Figure 1.1). During the harvest season harvesters from different areas, including those from Kgagodi-Tamasane, gather at the outbreak areas to harvest mopane worms. The harvesters prefer to establish their temporary settlements near tarred roads, especially the A1 highway, to harvest and sell their product to the road users.

The outbreak of mopane worms occurs in summer, a time during which rainfall and temperatures are high (Styles, 1996; Dithlogo, 1996). Mopane worm seasons occur during months of December/January and April/May (Mpuchane *et al.*, 2000).

The natural vegetation throughout the study area is mainly mopane woodland and thorny savanna shrubs which cover the North and Eastern parts of the country (Mojeremane and Kgathi, 2005). Intact vegetation is found around Tamasane and Kgagodi villages, though there are different land uses such as arable and pastoral farming. Mopane worms are generally harvested from communal lands (Mojeremane and Kgathi, 2005).

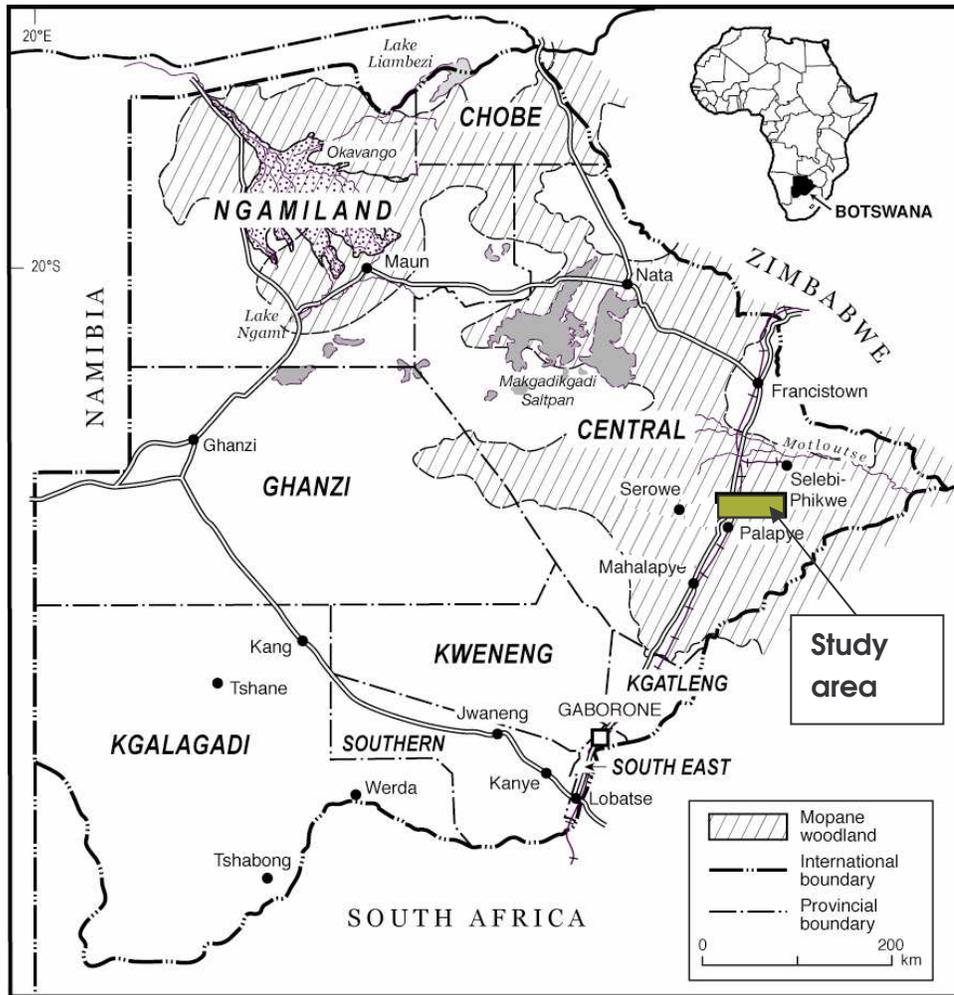


Figure 1.1 Mopane woodland coverage in Botswana and the study area (After Marias, 1996; modified by Mrs Wendy Job, 2009).

The criterion for selection of the study area was based on its location and its accessibility. The study area is very close to one of the busiest roads in Botswana, thus making it easy to access using public transport. This is one of the locations that attract a large number of the harvesters during the mopane worm harvesting season (*Mmegi the Reporter*, 18 April 2008) thus making the area eligible for research.. Moreover, the criterion for selection of the area based on the fact that the researcher is a resident of the area and could establish a rapport with the respondents more quickly, thus lessening any possibly intimidation of the respondents.

2. Literature Review

2.1 Introduction

The literature review presents the socioeconomic and environmental impacts of natural resource use in developing countries and specifically in regards to non-timber forest products (NTFPs) and mopane worms. The purpose of this literature review is also to highlight and analyse what is known about the harvesting of mopane worms, in terms of harvesting practices, their evolution, and the impacts they have on the mopane worms and their habitat in southern Africa. The review is organised thematically, discussing the rural livelihood strategies both in developing countries and in Southern Africa in particular. The review is then narrowed to look at the importance of mopane worms, the harvesting practices, the commercialization of mopane worms, as well as the environmental impacts of the harvesting of mopane worms. This is to reveal the ideas and the relationship between these aspects and the gaps that exist in relation to this study.

2.2 Rural Livelihood Strategies in Developing Countries

Sustaining livelihoods has always been at the core of human activities. Various strategies and activities have been put in place to better the well-being of people. According to Prescott-Allen (2001), human well-being is the ability of all people to determine and meet their needs, and have a wide range of choices and opportunities to fulfil their potential. Sustainable livelihoods however, are not only about meeting household food security, but also about having opportunities for investment and business, and national economic stability (Africa Environment Outlook 2, 2006).

Various strategies and activities have been utilised overtime to sustain the well-being of people in developing countries. As Ellis (2000) describes, livelihood activities can be divided into two main categories: natural resource, and non-natural resource-based activities. The natural resource-based activities include collection and gathering from forests and woodlands, agriculture, brick making, fishing, weaving and thatching. The non-natural based activities are activities such as rural trade, rural services, and

remittances and pension from former formal sector employment (Ellis, 2000). Livelihood strategies and activities vary from area to area, depending on what is available, the know-how the community possesses and other influencing factors. These strategies can include farm and non-farm income earning opportunities. In the case of most, if not all developing countries, income and services derived from natural resources that include land, forests and woodlands, non-timber forest products (NTFPs), freshwater and wetlands, coastal and marine resources, and wildlife (flora and fauna) are central to the livelihoods of many rural people and to countries' economies (UNEP-Africa Environment Outlook 2, 2006).

While there are benefits that are being drawn from utilising the natural resources such as sustaining livelihoods, there are cases of overexploitation which are of serious concern across the globe (Miller Jr., 2002). Many communities in developing countries are poor, so with limited or no alternative livelihood strategies, they tend to overuse the available natural resources. For instance, UNDP (2004) shows that more than 220 million hectares of tropical forests were destroyed during 1975-1990 mainly for food production, while about 20% of the world's pasture and rangelands have been damaged with the most severe losses in Africa and Asia. However, Lambin *et al.* (2001) warn of simplifications and myths of cause-consequence relations where in most cases issues such as population growth and poverty are blamed for land-cover change and environmental degradation. He and co-researchers highlight that the cases they have reviewed support the conclusion that neither population nor poverty alone constitutes the sole and major underlying causes of land-cover change worldwide. Rather, peoples' responses to economic opportunities, as mediated by institutional factors, drive land-cover changes (Lambin *et al.*, 2001). This is important in understanding the complexities surrounding natural resource use, in this case mopane worm harvesting and harvest practices, thus providing an opportunity for thorough investigation of all issues involved.

2.2.1 Rural Livelihood Strategies in Southern Africa

Communal rural communities of southern Africa are no different from other areas of the developing world that exploit a wide variety of natural resources for home consumption and/or sale (Bradley and Dewees, 1993; McGregor, 1995; Ainslie *et al.*, 1996; Clarke *et al.*, 1996; Campbell *et al.*, 1997; Cunningham, 1997; Shackleton and Shackleton, 2000). In southern Africa, approximately 80% of the poor live in rural areas and are dependent on agriculture for their livelihoods. Many residents of communal areas in Southern Africa still consider farming as the most important rural livelihood strategy although there are other non-agricultural strategies and activities that they employ to increase and stabilize their incomes (Bryceson, 2000; Chapman and Tripp, 2004; Babulo *et al.*, 2009).

The use of non-timber forest products (NTFPs) for household consumption and for sale is prevalent among rural communities in Southern Africa (Angelsen and Wunder, 2003; Belcher *et al.*, 2005). In recent years with an increasing focus on poverty alleviation, NTFPs have been considered for their role in minimizing the impact of crises on rural households and as a possible means to assist households to move out of poverty (Angelsen and Wunder, 2003; Belcher *et al.*, 2005). According to Wunder (2001) there is increasing evidence of natural resources serving as “the poor man’s overcoat”, enabling poor households to be food secure. NTFPs are used to meet basic needs such as food and shelter, as well as economic needs. At times they serve as safety-nets (Chopra, 1997; Khare *et al.*, 2000; Angelsen and Wunder, 2003). Some studies have shown that with the prevalence of HIV/AIDS, some urban families have now shifted to relying on NTFPs to alleviate poverty as it is cheaper compared to other strategies. A study done by Hunter *et al.* (2007) further reveals that the loss of a productive household member (bread winner) to HIV/AIDS has resulted in families in southern Africa solely relying on natural resources, especially NTFPs for food security. Significantly, this study brings in the link between food security, HIV/AIDS and ‘natural capital’, thus providing very useful insight in the quest to understand the evolution of the harvesting practices of mopane worms. Furthermore, studies such as this assist in understanding the complexities underlying the use and overuse of natural resources, instead of the parochial focus on the

cause and effect most studies use, as already highlighted by Lambin *et al.* (2001). Within its methods, this study provides a step towards participatory decision-making by providing a baseline of perceptions held by NTFP users in Botswana.

Of the wide range of NTFPs, entomophagy, (the eating of insects by humans) is common and has been going on for decades in different parts of the world. Research by DeFoliart (1995) has established that about 1000 insect species have been used as traditional foods by humans and they still form an important part of the nutritional intake and economy of many societies. Insects have always been part of the diet for rural communities in Africa (Illgner and Nel, 2000). “Insects provide a good source of proteins, minerals, vitamins and energy, they can cost less than animal protein for poor rural communities and their consumption has averted many cases of malnutrition”(Teffo *et al.*, 2007, 434).

Some of the insects consumed in Africa are grasshoppers, termites, bees, caterpillars, stink-bugs, jewel beetles and white grubs (Agbidye *et al.*, 2009). The edible stink bug *encosternum (Haplosterna) delegorguei* Spinola (*Heteroptera, Hemiptera*) or *thongolifha* in Venda is a delicacy to Venda people living in Limpopo province in South Africa (Teffo *et al.*, 2007). According to Teffo *et al.* (2007) the consumption and selling of *thongolifha* is common in Limpopo Province. The bugs are eaten raw, dried or with stiff porridge. It contains reasonable levels of protein, vitamins, some amino acids and minerals.

In the State of Benue in Nigeria the consumption of more than ten insects is common while in Zambia the consumption of caterpillars of eight saturniidae moth species have been reported among the Bisa people (Agbidye *et al.*, 2009; Mbata and Chidumayo, 2003). Because of the widespread consumption of insects as a cultural and food security practice and increasing commercialization of insect crops, there is a likelihood of unsustainable harvesting (Teffo *et al.*, 2007). It should be noted that the degradation of natural resources presents a real threat to the food security and cultural wealth of rural people as reported for mopane worm harvesting in southern Africa (Agbidye *et al.*, 2009).

2.3 The Importance of Mopane Worms

Mopane worms are a valuable NTFP resource that contributes substantially to rural economies and nutrition in mopane forest areas. Several studies reveal that mopane worms are best known and most economically important non-timber resource products of the mopane woodland in Mozambique, Malawi, Southern Zimbabwe, Northern South Africa and North, East and Central Botswana (Dreyer and Wehmeyer, 1982; Bradley and Dewes, 1993; Timberlake, 1996; Moruakgomo 1996; Gashe and Mpuchane, 1996; Styles, 1996; Onigbinde and Adamolekun, 1998). Traditionally, the mopane worm used to be an important food source for the rural communities within the range of mopane woodland, but “it is now widely eaten across Southern Africa where it has become an important trading commodity” (Stack *et al.*, 2003, 1). These worms still remain a delicacy to many people in southern Africa, despite the dominance of Western cuisine (Illgner and Nel, 2000).

In southern Africa the harvest of mopane worms is one of the ways through which local communities diversify their livelihoods. Whereas harvesting of mopane worms was traditionally undertaken for subsistence and nutritional purposes, commercialization of the resource has become common in recent years. Marketing chains of mopane worms extend between countries in southern Africa (Ashipala *et al.*, 1996; Marias 1996; Rebe 1999; Stack *et al.*, 2003).

Rural communities in Botswana pursue a diverse portfolio of farm and non-farm activities to sustain their livelihoods. Mopane worm harvesting is one of the ways through which rural communities boost their household economies and nutrition (Allotey *et al.*, 1996; Moruakgomo 1996; Ghazoul, 2006). Mopane worms are harvested for both subsistence and commercial purposes, including bartering (Stack *et al.*, 2003). The harvesting of mopane worms is a business that provides seasonal employment to many rural people in Botswana (Mpuchane *et al.*, 2000). The income is normally used for different purposes such as purchasing grain, foodstuffs, paying school fees, buying kitchen utensils, paying medical bills, travel, although mopane income on its own is

insufficient to cover all these expenditures (Stack *et al.*, 2003).

Studies conducted on the nutritional value of mopane worms reveal that mopane worms contain high levels of crude protein (van Voorthuizen, 1976; Sekhwela, 1989; Ohiokpehai *et al.*, 1996; Madibela *et al.*, 2008), high concentrations of calcium and phosphorus, amino acids, and crude fat (Sekhwela, 1989; Zinzombe and George 1994; Ohiokpehai *et al.*, 1996; Motshegwe *et al.*, 1998). It has been discovered that mopane worms compare favourably with meat and fish in terms of protein, fat, vitamin and caloric content. Mopane worms have also been recommended as a supplement for high cereal diets and infant foods (Ohiokpehai *et al.*, 1996). The worms are also a valuable source of nutrition for rural communities, especially for vulnerable groups such as pregnant women, lactating mothers and children (Moruakgomo, 1996).

Mopane worms are consumed as both a relish and a snack. They are generally fried, roasted, or cooked in a stew with vegetables and other foods or served as relish with maize meal porridge (van Voorthuizen, 1976; Menzel and D'Aluisio, 1998). Therefore increased supplies of mopane worm in both rural and urban areas have the potential to address food security problems both by increasing incomes for poor mopane harvesters and by increasing the availability of a high-protein food.

Mopane worms represent a potential source of protein in diets of livestock. There is evidence that mopane worms exported out of Botswana to South Africa are used predominantly for stock feed though it is not known how the animals fed on the worms are performing (Mpuchane *et al.*, 2000). However, amino acids in mopane worms are vital for supporting the immunity system in parasitized animals, and for foetal growth, and milk production (Hoskin *et al.*, 2002; and Madibela *et al.*, 2008).

2.3.1 Commercialization of Mopane worms

“Most of the agricultural officers and social workers agree that the phane (mopane) trade is the largest veldt product commercial activity in Botswana ... (and) may be second only to agri- culture as the source of livelihood for the rural communities in

the mop(h)ane woodland” (Moruakgomo, 1996, 34).

Commercialization of mopane worms has become quite common in southern Africa (Hobane, 1994; 1995; Marias, 1996; Kozanayi and Frost, 2002). The shift from subsistence to commercial use resulted from increased demand due to changing diets and economic pressures in urban centres, as well as from cultural interactions. There is evidence of marketing chains extending from southern Zimbabwe and eastern Botswana to South Africa, Zambia and the Democratic Republic of the Congo, as well as nationally within the main producing countries: Botswana; Namibia; South Africa; and Zimbabwe (Kozanayi and Frost, 2002). According to a research study by Kozanayi and Frost (2002) on mopane worm marketing chains, it is not only the rural poor who engage in harvesting and trading mopane worms, but a whole range of people who are interested in the gains brought about by the trading of mopane worms. It is not surprising that “large scale organised harvesting has entered the scene, accompanied by.....unsustainable over-collection” (Gullan, *et al.*, 2005, 19).

Botswana is seen as the largest producer of mopane worms for the open market (Allotey *et al.*, 1996) and exports to South Africa which is the main buyer (*Mmegi the Reporter*, 2008) and has a potential market for tens of thousands of tonnes (Molose, 1997). According to Styles (1995), in Botswana the mopane worm harvest in good years is estimated to be worth US\$3.3 million, providing employment to 10 000 people. However it is not known whether these figures account for the situation in every year or just the situation at the time of study. Also, there has been little research on the nature and dynamics of the marketing chains, markets or traders involved in Botswana. Therefore it is not known how much this business is contributing to improvement of rural livelihoods, and to the Gross Domestic Product. Further study is needed on this area as this is outside the scope of this study.

Commercialisation of the mopane worm trade in southern Africa has led to over-harvesting with harvesters now collecting largely more than a single person would have traditionally harvested for family consumption alone (Ghazoul, 2006). Coupled with reports of over-harvesting there is also a severe lack in basic knowledge needed to

manage mopane woodlands in the face of increasing and multiple resource demands. The need for the broader management of mopane woodland stems from the use of woodlands as sources of building material, firewood, charcoal production, rope and medicine (Ghazoul, 2006). Mopane woodland studies are therefore necessary to meet the demands of multiple resource management.

Mopane worms are generally harvested from communal woodlands. As a consequence of the good returns associated with mopane worm trading, and the fact that outbreaks occur in different areas from year to year, it is now common to find people using motorised transport to harvest mopane worms for commercial purposes and far from their local communities (Ashipala *et al.*, 1996). This increased harvesting pressure may be causing social and ecological problems. Outsiders are less likely to ask for permission to collect and more likely to strip the resource. In return, local communities are attempting to impose rules on worm collection, but in the context of a management system where these have never existed before, and where little is known about scientific management of mopane generally, this is bound to fail (Timberlake, 1996). Problems of resource access, resource supply and community conflict appear to be emerging in response to mopane worm commercialisation (Ashipala *et al.*, 1996). Although this lay outside the scope of this research study, it enhances understanding of the complexities that underlie the harvesting of mopane worms, including the harvesting practices harvesters engage in.

2.3.2 The Harvesting and Harvesting Practices of Mopane worms

The collection and processing of mopane worms involves all genders. Traditionally it was considered as the women's task (Stack *et al.*, 2003). Although the number of women (constituting 96% of harvesters) and children still predominate, participation of men and youth has increased extensively due to various reasons such as the collapse of some livelihood strategies, and the lucrative business of mopane worms (Stack *et al.*, 2003).

The harvesting of mopane worms depends on the host plant, culture and tradition of particular tribes (Gashe and Mpuchane, 1996). For instance, in Zimbabwe the harvesting

takes place around homesteads where mopane trees are found, in communal grazing areas, on large scale commercial farms and on state farms, with commercial farms being a very important source of the product (Stack *et al.*, 2003). On the other hand in Botswana, much of the mopane belt is located in communal areas where customary law allows anyone to harvest (Stack *et al.*, 2003).

Every year there may be two harvests of mopane worms depending on the amount of rainfall received during that season (Ellgner and Nel, 2000). In 2000, Mphuchane reported that the harvest of mopane worms in Botswana was during the months of December-January and April-May, while in 2005, Toms and Thangwana reported that the first harvest of mopane worms was between November and January and March-May. These findings indicate a possible extension of harvesting seasons in recent years.

According to Stack *et al.* (2003) the harvesting of mopane worms entails their collection from both the ground and from trees, usually at the 5th instar stage and the last stage before pupation. Stack *et al.* (2003) further explains that mopane worms collected from the ground (about to pupate) generally have little digested food in their guts and are easier to process. However, most mopane worms are collected from the trees while still feeding and so they have to be thoroughly processed to remove all undigested material from their gut (Toms and Thangwana, 2005). Worms are collected by shaking the tree or by direct collecting from foliage (Gullan *et al.*, 2005).

The harvesting and processing of mopane worms throughout the mopane belt is still traditional in nature but extensive destruction of trees in order to speed up the collection process is increasingly identified as a problem (Stack *et al.*, 2003). There are no modern technologies or equipment used during the harvest, except the occasional use of gloves to protect hands from the sharp spines during collection and degutting (Stack *et al.*, 2003). Gashe and Mphuchane (1996) confirm that the harvesting practices are similar in most southern Africa countries like Zimbabwe, Botswana and South Africa.

The harvesting of mopane worms has increasingly become a common phenomenon not

limited to the rural poor people but it is an activity undertaken by all social categories of people (Stack *et al.*, 2003). It is revealed that “limited income earning opportunities and low income levels throughout these communities encourage almost all households to take advantage of a ‘free forest resource’, particularly one that is available at a time of year when stored supplies of staples are finished and the new crop is only just planted” (Stack *et al.*, 2003,5). However, research reveals that the abundance of mopane worms is declining due to a number of factors: such as increased exploitation, and decrease in selective harvesting, as well as pressure on mopane woodlands due to some other uses. For instance in Botswana it has been observed that mopane moths have disappeared in some areas due to heavy harvesting (Hobane, 1994; Bartlett, 1996; Roberts, 1998).). Other factors include soil type, rainfall, predators, browse quality, and the decline of mopane woodlands (Styles, 1996; Marias, 1996).

Over-exploitation is a looming problem due to increasing demand for mopane worms which its management is wholly based on traditional knowledge and experience. This is because “with no quantifiable database, monitoring system, or sound biological knowledge, traditional knowledge may not be able to support a sustainable harvesting regime” (Maviya and Gumbo, 2005, 96). It is also not known whether the practices of harvesting mopane worms vary between subsistence and commercial harvesters, whether there are any new practices introduced, and how they impact on the host environment.

The outbreak of mopane worms can be sporadic, causing people to travel considerable distances to outbreak sites and often camp for several days in the collection area while harvesting. Hence there has been an emergence of informal settlements at breakout sites in recent years (Stack *et al.*, 2003). However, the impacts of informal settlements on the environment during the harvest of mopane worms are not known since no study has been conducted on them. Moreover, there is very little research on the harvesting practices, the evolution of the harvest practices and the resultant impacts on the resource and its host, despite several studies that have been conducted on mopane worms. This is the gap which this study seeks to close.

The decline in the abundance of mopane worms is said to result from both increasing exploitation and reduction in mopane woodlands. Decline in selective harvesting (where the harvesters wait until the caterpillars are at a certain stage) due to increased commercialization is claimed to have reduced moth numbers (Hobane 1994; Bartlett 1996; Gullan *et al.*, 2005). Some harvesting practices such as the felling or branch-logging to enable caterpillars in the canopy to be brought within reach, pose serious threats to the abundance of the worms. Also, debarking and the collection of branches and trunks for firewood and construction purposes have led to the removal of many mopane trees, threatening the availability of the worms (Illgner and Nel, 2000). Studies reveal that the decline in mopane woodlands will ultimately affect the abundance of mopane worms. On the contrary, Gullan *et al.* (2005) argue that the years of reduced mopane worm harvest are associated with climate-induced drought than with unsustainable harvesting of the resource. Although this may be the case, the findings are unable to provide convincing evidence in the case of Botswana since they are regional-based (southern Africa). Evidently further study and careful data interpretation is needed, hence this study.

2.4 Conclusion

The literature review has examined the mainstream ideas, findings and discoveries on the socioeconomic and environmental impacts of mopane worm harvesting to show that they are not new concepts. As it is the case with most NTFPs in southern Africa, there is increasing pressure on mopane worms. Several studies carried out in southern Africa on mopane worms have shown that the demand for mopane worms is increasing due to commercialization of the product which has a wide market in countries like South Africa (Hobane 1994; Bartlett 1996; Stack *et al.*, 2003; Gullan *et al.*, 2005). This has resulted in overexploitation of the resource in some areas. However, the impacts brought by overexploitation of mopane worms on the environment, especially on the mopane woodlands, due to increased commercialization have not been researched in depth. These studies strengthen a case for research in assessing the change in harvesting practices of mopane worms, the causes of change as well as the perceptions that harvesters have about the impacts of current harvesting practices.

3. Methodology

3.1 Introduction

This chapter examines the subjective approach used in this study to illuminate its central questions about the evolution of harvesting practices of mopane worms, motivations for harvesting mopane worms, and perceptions of the harvesters regarding the impacts of current mopane worm harvesting practices in central Botswana. It discusses the method of research used, the respondents of the study, the sampling technique, the data collection techniques used, the validation of the techniques, the administration of the techniques and the statistical treatment of the data that has been gathered.

3.2 Method of Research

To achieve the aim of this research, a subjective approach was used, not least because of the possibilities it presented for innovation and for answering the research questions using a case study. There are two basic styles of research; *objective* and *subjective*. Objective approaches are concerned with the physical characteristics and the external world, universally applicable rules and laws, tested through hypothesis, experiment and survey. Subjective approaches deal with the created social lives of groups and individuals through observation and explanation (Swetnam, 2000). That is where this study found its place.

Subjective approaches are normally case-study based, that is, they solely rely on primary data. The primary data in this study were collected using both observation and descriptive practices of research (core components of case studies). The observational approach was used to gather data on the harvest practices and strategies that the harvesters employed, as well as the impacts of the harvest practices. Field notes were made during the observations. A descriptive method on the other hand was used to obtain information concerning the current status of the phenomena to describe "what exists" with respect to variables or conditions in a situation (Creswell, 1994). This method (through semi-structured interviews) was used to collect data on the harvesters' motivations for harvesting mopane worms, harvesting practices, the way they have

changed over the years, and the causes of change.

The study was solely dependent on primary data. The researcher depended on data observed and collected directly from first hand experience. Questions were tailored in such a way that only the needed information was collected, yet were left open ended.

3.3 Sampling

When acquiring information about a relatively small part of a larger group or population, it is vital that a sample is as representative as it can be, so that useful generalizations can be made (Rice, 2003). Although there are many sampling practices such as random, simple random, systematic and stratified sampling (Cochran, 1977; Kalton, 1983; Ardilly and Tille, 2006) which are probability-based, this study opted to use a non-probability method namely *purposive sampling*. This method is not statistically rigorous in terms of representation (Rice, 2003) but the units that are selected are ‘information-rich’ (Patton, 1990). This sampling technique was preferred above other techniques because studying information-rich cases yields insights and in-depth understanding rather than empirical generalizations as it is the case with other strategies (Burns and Grove, 2005). Interviewing mopane worm harvesters only, resulted in the accurate representation of the population.

Harvesters from three informal settlements and two villages were interviewed. *Snowball sampling* was used, whereby someone who met the criteria for inclusion in the study was included and this person then recommended another person who also met the criteria (<http://www.statpac.com/>). Harvesters led the researcher to other harvesters, thus rendering the whole process easy, and time and cost effective.

The study interviewed 10 people per village. About fifty percent of the harvesters in the selected three informal settlements were interviewed. Each informal settlement had on average a population size of 10 to 20 harvesters, including children who normally accompany their parents to help in the process of harvesting. However, only adults from the age of 18 years were interviewed. In addition, the harvesters who had been

participating in harvesting for quite a long time (preferably two decades) were purposefully selected for interview so that historical information on harvesting could be gathered. Total of 50 people were interviewed.

3.4 Data Collection Techniques

The data collection in this research study relied on qualitative methods since the study was based on researching patterns and behaviors of respondents. The techniques that were used to gather the data were semi-structured interviews and participant observations.

3.4.1 Semi-structured Interviews

A semi-structured interview is a verbal interchange where one person, the interviewer, attempts to elicit information from another person by asking questions (Longhurst, 2003). Semi structured interviews were conducted with a fairly open framework which allowed for focused, conversational, two-way communication. As is it the case, semi-structured interviews are normally flexible, allowing new questions to be brought up during the interview as a result of what the interviewee says; hence they are sometimes referred to as informal, conversational or 'soft' interviews (Longhurst, 2003). Though they are flexible as already stated, it is generally beneficial for interviewers to have an interview guide prepared, which is an informal "grouping of topics and questions that the interviewer can ask in different ways for different participants" (Lindlof and Taylor, 2002, 195).

Semi-structured interviews were used to collect data on the harvesting practices and their evolution and harvesters motivations for harvesting mopane worms. The researcher prepared interview guides to help her to focus an interview on the topics at hand at the same time not constraining herself to a particular format (Appendices A, B and C). This freedom helped the interviewer to tailor questions to the interview situation, and to the people she was interviewing (Lindlof and Taylor, 2002). Semi structured interviews were also seen as the most adequate tool to capture how interviewee perceived a particular

domain; hence the technique was preferred over other practices.

Semi-structured interviews require interviewing skills, and they are time-consuming and resource intensive. To address these challenges, questions were short, straight forward and open-ended. A face-to-face method was preferred in conducting semi-structured interviews as it is cost effective. Interviews were conducted in the native language; Setswana. Some of the informal settlements harvesters were interviewed in their campsites while some were followed into the bush. In the villages interviews were conducted in people's homes. Twenty harvesters from the villages were interviewed while thirty harvesters from informal settlements were interviewed.

3.4.2 Participant Observation

Participant observation involves spending time being, living or working with people or communities in order to understand them (Laurier, 2003). This method involves the researcher "getting to know" the people they are studying by entering their world and participating - either openly or secretly - in that world. The advantages of this method are: flexibility; and high probability of generating highly detailed, high-quality information about people's behaviour. The researcher's understanding of the phenomenon under study is also deepened. The disadvantages on the other hand are that it is time consuming; documenting data is difficult; and it is an inherently subjective exercise, whereas the research requires objectivity (Johnson, 1990). Participant observation data consists mainly of the detailed field notes that the researcher records in a field notebook. Although typically textual, such data may also include maps and other diagrams, such as organizational charts (Johnson, 1990).

Participant observations were used to gather data on the informal settlements and harvesting practices (Table 3.1). These were done during the harvesting season. The observations however were done without the harvesters' knowledge that they were being observed. This technique is called *unobtrusive observation* (Powell and Steele, 1996). Unobtrusive observation seemed appealing since people behave differently when they know that they are being observed. The observation process was used to supplement data

on harvest practices that was collected through the administration of semi structured interviews. Observations were done concurrently with the semi structured interviews.

The presence of the researcher in the field could not be overlooked as it may have influenced the outcomes of data collection process. As Patton (2002) highlights, the presence of an observer/investigator can distort the findings of a study due to the biases of the researcher. Furthermore, the observed may behave when they are aware that they are observed, and may be intimidated by the presence of the observer/researcher. In attempt to minimize these effects, the observer began by establishing a rapport with the harvesters. It helped that the researcher is a resident of this area. However the period of establishing rapport was rather short due to time constraints and there is likelihood that this affected the findings in some way.

Table 3.1 A sample of what was observed during participant observation.

Category	Includes	Researcher should note
Cooperation between the harvesters	-How close are the harvesters to one another? -Cooperation and interaction between the harvesters	-What individuals' preferences concerning personal space suggest about their relationships
Harvesting practices	-What practices do harvesters use; any equipment used to speed up harvesting?	-Any evidence of broken tree branches; equipment; do harvesters shake or cut trees; and so on.
Informal settlements	-what are they made of? -space between them? -population size -environmental issues	

This process of data collection was complicated by the potential risks, dangers and hazards that naturally exist in the harvest areas that were consistent with any forest environment. Field notes were taken during the observation period to document certain participant observation activities, such as informal or spontaneous interviews,

observation, and generally moving about in the field. These handwritten notes were later expanded and converted into computer files.

3.5 Data Analysis

The data collected during field survey were coded and analysed, and recommendations were made accordingly. Coding is the development and use of a language that will be used to convert data into a form that is appropriate for data analysis and reporting results. It can also be seen as a process combing the data for themes, ideas and categories and then marking similar passages of text with a code label so that they can easily be retrieved at a later stage for further comparison and analysis (Auerbach and Silverstein, 2003). Coding the data made it easier to search the data, to make comparisons and to identify any patterns that required further investigation. Coding was based on themes, topics, phrases and keywords found in the data. Field notes, data/transcripts from interviews, and field survey observations were analysed by indexing and sorting them out by theme or topic in question (classification).

4. Results and Discussion

4.1 Introduction

The purpose of the research study was to find out how mopane worm harvesting practices have evolved, to expose motivations for harvesting mopane worms, and to investigate whether the change (if any) in harvesting practices has impacts on the mopane worms and the mopane woodlands. The study was based on the perceptions of the harvesters in the Tamasane-Kgagodi area. This was done through conducting semi-structured interviews and field observations in the identified breakout areas. This section presents the findings from the data gathered between November and December 2009, in the Tamasane-Kgagodi area in Central District, Botswana.

This section will first describe data demographics of the mopane worm harvesters: their age, places of origin and their experience in harvesting mopane worms. Secondly an analytical discussion of the study's results organised thematically, will be presented. The three thematic topics include mopane worm harvesting trends, motivations for harvesting mopane worms and impacts of the current harvesting practices on mopane worms and their habitat. A summary of the findings is provided last.

4.2 Data demographics

Harvesters from two villages (Kgagodi and Tamasane) and three informal settlements around the Tamasane-Kgagodi area were interviewed. Purposive sampling technique, a non-probability method, was used to determine the sample. Out of 50 harvesters interviewed, 30 were from three informal settlements; 10 were from Tamasane village; and the other 10 from Kgagodi village. Only 16 (32%) of the informants were males while the majority (34) were females. The age of the harvesters spread across all age categories, with those over 45 years large in number (Table 4.1).

Table 4.1 Demographics of the harvesters

Harvesters Age	Informal settlements	Tamasane	Kgagodi
25-34	8		
35-44	13		6
45+	9	10	4
TOTALS	30	10	10

Harvesters in the informal settlements originated from different places in the Central District (Figure 4.1). All harvesters were from within the Central district except the three from Gaborone city in the South East District. Most harvesters were from Mahalapye village, about 90 km from the harvest area (Table 4.2). This is the second closest area to the harvest area after Serowe which is 65 km away. Mopane worms in Botswana are generally harvested from communal woodlands. No limit is placed on collection as revealed by the Department of Forestry and Range Resources.

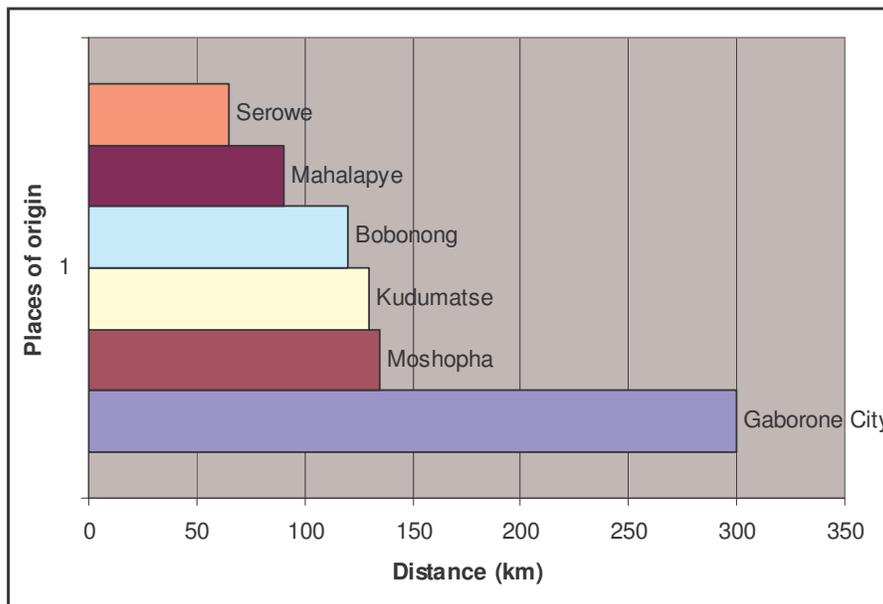


Figure 4.1 Places of origin and distance travelled by the mopane worm harvesters dwelling in informal settlements.

Table 4.2 Number of harvesters from each place of origin

Village	No.
Mahalapye	16
Serowe	9
Kudumatse	1
Moshopha	1
Gaborone city	3
Bobonong	3

The harvesters explained that they hired transport or alternatively used public transport to get to the harvest area. They further revealed that most of them do not own cars. In instances where the harvesters were hired to harvest the worms, the hirers transported them to and from the outbreak area. The harvesters' reasons for coming to Tamasane-Kgagodi area was that, although they had mopane trees in their places of origin, there were no mopane worms in their areas, that is, there was no outbreak in that particular year. General reasons given for no outbreak were: poor rainfall and extinction of mopane moths in certain areas. Although some places where the harvesters came from had mopane worms, they explained that they were inadequate hence the relocation. Some harvesters came from places that had no mopane trees at all such as Gaborone city. The harvesters in the informal settlements also stated that they preferred camping because it was expensive to commute.

The harvesters in Tamasane and Kgagodi villages on the other hand commuted to and from the harvest area. They explained that they harvest the worms on the periphery of their villages, about 1-5 kilometres from the villages. Only a few of them went as far as 10-15 kilometres using motorised transport. The harvesters in the two villages only resorted to camping in the bush when there were no worms in the vicinity. The two groups of harvesters revealed their experience (in terms of years) in harvesting mopane worms (Table 4.3).

Table 4.3 Experience in harvesting mopane worms

	Informal settlements	Tamasane village	Kgagodi village
Less than 5 years	14		
10-20 years	11		2
20+ years	5	10	8
Total	30	10	10

Most harvesters in the informal settlements had less experience in the harvest field compared to the harvesters in Tamasane and Kgagodi villages. Most of them, about 47%, had less than five years of harvesting mopane worms whereas in the villages 90% of the harvesters had more than twenty years of harvesting mopane worms. This correlates with the age of the harvesters since the majority (70%) of the harvesters in the informal settlements were aged between 25-44 years while in the villages (70%) were more than 45 years of age (Table 4.1).

The majority of the harvesters were poor. Poverty can be defined as “deprivation from resources (physical, economic, social etc) which are needed to achieve a sustainable livelihood” (Botswana, 2002, 36). World Bank (2000) defines poverty on the basis of income, i.e. income of roughly \$1 per day is an indication of living in poverty. In Botswana the recent poverty estimates indicate a national level prevalence rate of 30.1%. That is, nearly one-third of the population lives below the poverty datum line (Southern African Regional Poverty Network, 2007). It is higher in rural areas (Government of Botswana, 2002). In this study poverty is viewed as inability to meet one’s basic needs. Due to the prevalence of poverty among the harvesters, majority of them employed a number of rural livelihood strategies such as harvesting and selling of non-timber forest products (NTFPs) such thatching grass and wild berries, and small scale retailing such as running tuck shops and brewing traditional beer. Some depended on subsistence farming, while others relied on their family members, the government self-reliance programme (Ipelegeng), and the old age pension fund. Hence the conclusion that the poor form the

largest group of mopane worms harvesters, as already established by Stack *et al.* (2003). However, the utilisation of this forestry resource is not only limited to the poorest households, but is an activity undertaken by all social classes.

The survey further revealed that 23 out of 50 harvesters had more than 20 years of experience in harvesting mopane worms; 13 had between 10-20 years experience, while 14 had less than five years of harvesting experience. No thorough study has been conducted on the experience of the harvesters and its implications on the sustainability of mopane worm harvesting. This, if looked into, is likely to enhance knowledge and understanding in multifaceted issues that surround the sustainability of mopane worms.

4.3. Theme 1: Traditional and Current Mopane Worm Harvesting Trends

In investigating the evolution of harvesting, the following practices emerged as important: traditional harvesting practices, current harvesting practices, and a comparison of the two. Current harvesting practices which include common worm picking practices, informal settlements, taboos and gender issues in harvesting mopane worms will be explained in detail.

The utilisation and harvesting of non-timber forest products (NTFPs) have had historical and current importance in local economies and cultures of indigenous people. Today, with increased commercialization, NTFPs have come to play an important role in income generation and employment in many parts of the world (Angelsen and Wunder, 2003; Belcher *et al.*, 2005). However, increasing demand can lead people to disregard traditional harvesting practices in order to capture the value-added benefits (Sinha and Bawa, 2001). Mopane worm harvesters in Botswana identified practices used in the harvesting of mopane worms, and showed how they have evolved over the years as the main purpose for harvesting shifted from subsistence and nutritional to commercial (Table 4.4).

Table 4.4 Traditional and current harvesting practices

Traditional practices	Modern/current practices	
Bend tree branches	Bend tree branches + Climb trees	Practices in picking mopane worms
Collect from shorter trees	Collect from shorter trees	
Shake trees	Shake trees	
Use sticks to pull the worms down	Use sticks to pull the worms down	
Collect worms crawling on the ground	Collect worms crawling on the ground	
No protection for hands during degutting	Use of protective gloves for catching and degutting	
Harvest mature worms	Inconsiderate: can harvest immature worms	
Light harvesting	Heavy harvesting	How much to harvest
More women, less men	Increasing number of men and of youth	Gender issues
Intense belief in and adherence to taboos	Aware of taboos but not adhering to them.	Taboos
Strong village structures of authority: Price of mopane worms determined by the village chief, and the worms sold from <i>Kgotla</i> (public meeting area)	Weak structures of authority: Price is negotiated between the buyer and the seller.	Traditional structures of authority
Camp in small groups	Camping in large groups	Informal settlements during harvesting
Camping for few days (<1 week)	Camping for a long period (2-4 weeks)	

*light harvesting: ≤ 4 buckets (25 l) mainly for consumption

*heavy harvesting: >4 buckets (25 l). for consumption & commercialisation

*small group (<5 people) *large group (>5 people)

4.3.1. Traditional harvesting practices

Traditionally, harvesting of mopane worms was particularly for subsistence and nutritional purposes. Rural women were active in the harvest of the worms while their male counterparts were involved in other rural household livelihood activities such as agricultural production and livestock rearing (Ghazoul, 2006). The long term harvesters (those who have been harvesting for more than 20 years) highlighted that rural women, often assisted by children, engaged in light harvesting of the worms. The period was usually shorter (less than a week). They collected worms from shorter trees, by bending tree branches, shaking trees and collecting worms crawling on the ground. The harvest of mopane worms was managed by an intense belief in the taboos that all the harvesters obeyed. Also, where selling was involved, traditional structures of authority played an important role in deciding the price of the worms. Where camping was involved, the harvesters camped for a short period, a week at most. It usually involved few people (2-5 people), and often related (Table 4.4). In some instances, instead of establishing informal settlements, the harvesters moved in with their relatives in the cattleposts near the breakout areas. The harvesters pointed out that the harvesters were few; therefore there was no pressure on the availability of the worms. Hence camping was not common. Shortage of the worms was only experienced during drought seasons when the rainfall was very low.

4.3.2. Current harvesting practices among the harvesters

Current harvesting practices will be discussed first by looking at the common practices in the picking of mopane worms, then the development of informal settlements will be reported on, thirdly taboos related to mopane worm harvesting and finally gender issues in the harvesting of mopane worms will be explained.

(a) Common Practices in the picking of mopane worms

Current practices in the picking of mopane worms in central Botswana do not differ significantly from traditional practices. The harvesters engage in practices such as shaking trees or climbing the trees, bending infested tree branches, 'plucking' the worms

from short trees, and collecting worms crawling on the ground; which were common among conventional harvesters (Table 4.4).

Harvesters employed more than one method of harvesting, with more than 80 percent of harvesters handpicking the worms by bending infested tree branches, collecting from short trees where the worms are easily accessible, and collecting from the ground the worms that are big enough and ready to pupate (Table 4.5). The harvesters highlighted that these were the easiest and quickest ways of harvesting the worms. Some of the harvesters caught the worms and degutted them in the bush while others took them to the campsite and degutted them there. The discovery that the harvesters did not break tree branches was intriguing because this practice is reported in other studies in response to increasing harvesters (Gullan *et al.*, 2005). Here the number of harvesters had increased but it has not resulted in those same “short cuts”. Interestingly both the resident and the immigrant harvesters revealed that they did not break trees branches because they were aware of the subsequent adverse impacts such as the lessening or even disappearance of mopane worms.

Table 4.5 Current harvesting practices-picking of the worms (number of respondents)

ACTIVITY	STTL 1	STTL 2	STTL 3	TAMASANE	KGAGODI
A. Bend tree branches, collect from short trees, and collect from the ground	5	7	12	9	8
B. use sticks + A	1		1		
C. shake trees + A			1	1	2
D. use sticks + C + A		1			
E. climb trees + A	1				
TOTAL (HARVESTERS)	7	9	14	10	10

Climbing trees and use of sticks as a way of harvesting were the least popular practices among the harvesters. Harvesters explained that they did not climb trees for fear of falling and because of snakes and monitor lizards. The harvesters who shook trees explained that mature worms do not hold firmly to the tree branches like immature ones, and thus are susceptible to falling when the tree is shaken. However, only few harvesters seemed to possess this knowledge, or rather, the fear of snakes and monitor lizards barred them from using this method of harvest.

(b) The development of informal settlements during mopane worm harvesting season

The practice of setting up informal settlements in the outbreak sites has been going on since 1970s but intensified in the 1990s due to what the harvesters identified as the financial benefits from trading in mopane worms. Back then the harvesters camped for not more than a week but this changed over time and today campers can stay in the bush for more than a month. The harvesters can move from one location to another, in search of the worms. Oftentimes the harvesters relocate when the worms are almost finished. Harvesters go back to their formal places only when satisfied with their harvest, or when there are no mopane worms to harvest.

The survey revealed that most harvesters were not novices in the setting up of informal settlements (Table 4.6). Statistics revealed that a high number of the harvesters were the second timers, followed by the third timers. From Table 4.6 conclusion that can be drawn is that majority of the harvesters were not new to the phenomenon of camping in the bush. This is an indication that the harvest of mopane worms is a lucrative activity.

Table 4.6 Experience in the harvest of mopane worms through establishing informal settlements

How long have you been harvesting mopane worms through establishing informal settlements in the breakout areas?						
	1st time	2nd time	3rd time	4th time	5th time	More than 5 times
	5	7	6	5	2	5
TOTAL	30 HARVESTERS					

The harvesters identified the advantages of staying in informal settlements: it is cost effective (they do not have enough resources to commute); they are closer to the outbreak area; the harvesting process is faster as the harvesters focus on harvesting only, and they can sell while harvesting as most settlements are established near the Botswana’s busiest highway A1.

(c) Perceptions of village harvesters regarding informal settlements

Improper harvesting practices such as harvesting immature worms have been reported as a common practice among the informal settlers. The village harvesters (most of them over 45 years of age) related the increase of informal settling to increased commercialisation of mopane worms. They blamed the campers for harvesting immature worms and for unearthing the worms that were about to pupate. They attributed the disappearance of mopane worms around their villages to the increasing number of the campers/informal settlers. Statements like ‘*basha ba baya phane botsetsi*’ meaning ‘young harvesters do not wait for the worms to reach maturity’ were common among the harvesters in the villages. The village harvesters pointed out that most of the harvesters in the informal settlements are young and inexperienced, thus they cannot tell whether the worm is ready for harvest or not. Nonetheless the informal settlers argued that since most of their catch was for commercial purposes, they could not afford to collect small worms

as most buyers were picky, so the practice is not common. Only four out of the twenty harvesters interviewed from Tamasane and Kgagodi villages confessed to often establishing informal settlements to harvest the worms.

The village harvesters claimed that they know that the worm is ready for harvest if it has shiny pricks, and when touched it does not spill green saliva like immature one, also, they have a yellowish substance at the anal opening, indicating that it is ready to pupate. They also pointed out that when the tree is shaken the mature worms do not resist falling off the tree like immature ones. In general the common yardstick of maturity is that the worms which are ready for harvesting should be human thumb finger size (about 2 cm diameter).

The number of mopane worm harvesters in Tamasane-Kgagodi area has been increasing annually due to economic benefits from trading in the resource. This has led to large scale harvesting, which was unheard of in the past. To meet the demand needs, harvesters have to catch as much worms as they can before the end of the harvest season, hence the proliferation of informal settlements in the break out areas. This is becoming a common phenomenon in Botswana.

Previous studies disclosed that the occurrence of outbreaks in different areas from year to year, resulted in people moving around by motorised transport to harvest mopane worms (Ashipala *et al.*, 1996). This behaviour changed over the years as people, instead of moving around in vehicles, established camps in the outbreak area (Stack *et al.*, 2003). In their study conducted in Botswana in Lerala and Maunatlala villages in the Central District, Stack *et al.* (2003) revealed that the maximum distance that the harvesters travelled to outbreak sites was 120km. Comparing Stack's findings with the current study, which revealed that the maximum distance was more than 300km, it can be concluded that mopane worm harvesting is attracting more and more harvesters annually from further afield.

There are no previous studies on the impacts of informal settlements in relation to mopane worm harvesting. The field observations made in three informal settlements during the harvesting season in December 2009 revealed that informal shelters were

made from mopane tree poles (taken from the surroundings, but usually reused every year) and strong plastic covers. However, some harvesters brought their own modern camping tents. Litter was well managed in the three sites. Such observations suggest that those informal settlements can have less of an impact than reported in other studies, but this required further investigation. As the number of harvesters and informal settlements continue to increase, there are likely to be significant adverse impacts on mopane woodlands and the worms, such as the destruction of mopane worm habitat and the lessening and ultimately the disappearance of mopane worms.

(d) Taboos in the harvesting of mopane worms

The widespread deterioration in traditional values especially among the present generations has led to disregard of taboos in the management of NTFPs (Mutanga, 2009). Taboos are cultural customs that forbid people to do, touch, use or talk about a certain thing (Oxford Advance Learner's Dictionary, 1998). Taboos and norms largely entail a societal beliefs and norms and guard the behaviour of individuals within a society. Their implementation and functionality largely solely depends on an individual view of point and those who mostly enforce them are local community members as opposed to outsiders in an area. Punishment for not abiding is solely rested in the spiritual world rather than existing local governance structures (Mutanga, 2009). However, with the widespread deterioration in traditional values especially among present generations these norms and taboos have greatly suffered. It has been observed that mopane worm harvesters in Botswana no longer follow taboos due to the weakening of the traditional leadership structures. The harvesters held different taboos but did not fully believe in and/or follow them. The three common taboos identified during the survey were: *phane ga e bewe botsetsi*- do not camp in the bush unless and until the worms are mature enough; forbidding the digging of worms that have gone underground, and boiling of mopane worms instead of roasting them. Regarding the first taboo harvesters believed that the worms would disappear if camping was done too early. However, the harvesters in informal settlements claimed that they usually come early before the worms are ready

for harvesting, not to harvest but to set up their temporary shelters. The harvesters in Tamasane and Kgagodi villages on the other hand accused the informal settlements harvesters for going early into the bush to harvest immature worms.

The second taboo was forbidding the digging of worms that have gone underground. The worms that burrow underground are those that have reached the final stage of growth and are ready to pupate, the stage at which they undergo complete transformation to become the adult moths (Athlopheng *et al.*, 1998). The digging of worms that have burrowed has been associated with the disappearance of the mopane worms in certain parts of southern Africa (Greyling *et al.*, 2001). The harvesters asserted that this practice was detrimental to the lifecycle of mopane worms. They reported that they have never seen anyone harvesting the worms in this way.

The last taboo emphasized boiling instead of roasting of mopane worms. Apparently this was the most popular and most observed taboo as all the harvesters in the informal settlements boiled the worms (Figure 4.2). The harvesters associated the disappearance of the worms with the failure to observe this taboo. The harvesters highlighted that it was easier to observe this taboo since they preferred boiling the worms in salty water as they tend to be tasty and clean, as compared to roasting them on hot ash. They further revealed that the buyers prefer boiled worms to roasted ones.

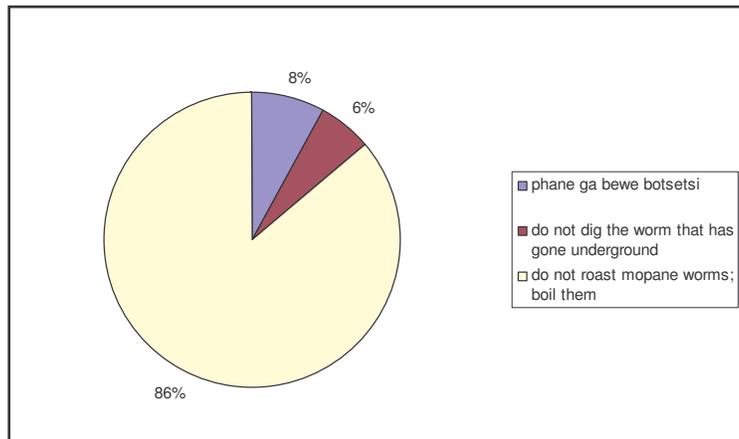


Figure 4.2 The popularity of mopane worm harvesting taboos among the harvesters.

The harvesters asserted that many years back, traditional leaders such as *dikgosi* (chiefs) used to place an embargo on the harvesting of larvae before or after a certain date. An embargo at the beginning of the season should prevent the over-exploitation of small larvae, which is a wasteful practice. However this has changed due to the limited powers of the traditional leadership structures. The harvesters affirmed that the taboos are no longer respected and fully followed.

The first two taboos are inclined towards sustainable harvesting of mopane worms by guarding the behaviour of the harvesters. If harvesters were to adhere to them, the prospects for mopane worm sustainable utilisation would be enhanced.

(e) Gender and mopane worm harvesting

Traditionally gender roles in harvesting of mopane worms had always been pronounced. The collection and processing of mopane worms was regarded as women's tasks (Harcourt, 2009). However, as confirmed by Martin and Villareal (1997), gender roles can change over time and in response to changing circumstances. This has been observed in the harvest of mopane worms as the participation by men and particularly youth, attracted by economic gains, is growing extensively (Stack *et al.*, 2003). Comparing 68% of women in Tamasane –Kgagodi harvesting area with 96% of the same gender group in Lerala-Maunatlala harvest area in 2003 in the same district (Stack *et al.*, 2003) it is evident that the number of men is increasing. Nevertheless, women still predominate. Both men and women are benefiting from mopane worm sales. A claim by Salma *et al.* (2001) that the sustainable harvesting of NTFPs by women for subsistence use has shifted to an overuse of the resources by men for income generation is yet to be verified,

especially in relation to mopane worms.

4.3.3. The relationship between traditional and current harvesting practices

Most traditional practices of harvesting mopane worms are still common today. The harvesters asserted that there has not been any significant change in the harvest practices over the years in terms of the picking of mopane worms from trees. As they asserted, most traditional practices remain unaltered, but there are some that have been ‘perfected’ with time to suit the era. The ‘worm picking’ practices of bending tree branches, shaking trees, browsing, and collecting worms from the ground, are still common and remain unaltered (Table 4.4). Contrary to the widespread destruction of trees in order to speed up collection process highlighted by Stack *et al.* (2003) survey, no destruction of trees was recorded in the Tamasane-Kgagodi area. Also, no improved technological devices were identified during fieldwork beside the use of gloves to protect hands from the sharp spines during collection and degutting. The harvesters explained that they could not use equipment such as step ladders as it would be cumbersome to carry them around.

According to the respondents the establishment of informal settlements in the outbreak sites is allegedly becoming common in Tamasane-Kgagodi area. This practice is probably promoted by the ever-escalating number of mopane worm harvesters in general. Also, the burgeoning market for mopane worms in the neighbouring countries such as South Africa has been associated with the changes in harvest practices of mopane worms. The expected increase cannot be taken lightly as it is likely to have serious implications on the sustainability of the mopane worms. However, the extent to which informal settlements may impact on mopane woodlands and mopane worms is not known due to the limitations of the study design, hence future studies in this area are necessary.

4.4. Theme 2: Motivations for Harvesting Mopane Worms in Central Botswana

Two primary reasons stand out which motivate people to harvest mopane worms: harvesting for commercial purposes and for household consumption.

People harvest mopane worms for different reasons. While harvesting for household consumption is still one of the reasons, the predominant motivation for harvesters is the quest for income generation (Akpalu *et al.*, 2009). The harvesters identified consumption, bartering, and commercial purposes as the main motivations for harvesting mopane worms (Figures 4.3 and 4.4).

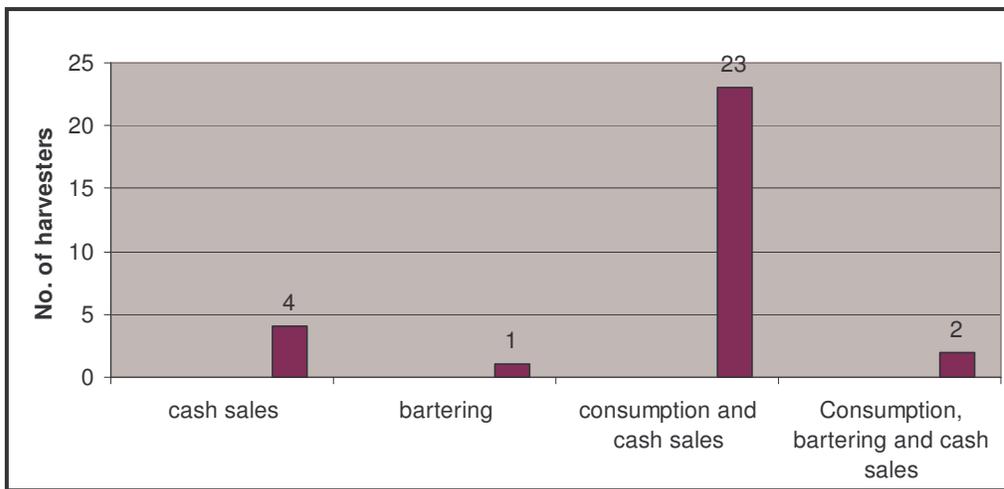


Figure 4.3 Reasons for harvesting mopane worms-informal settlements

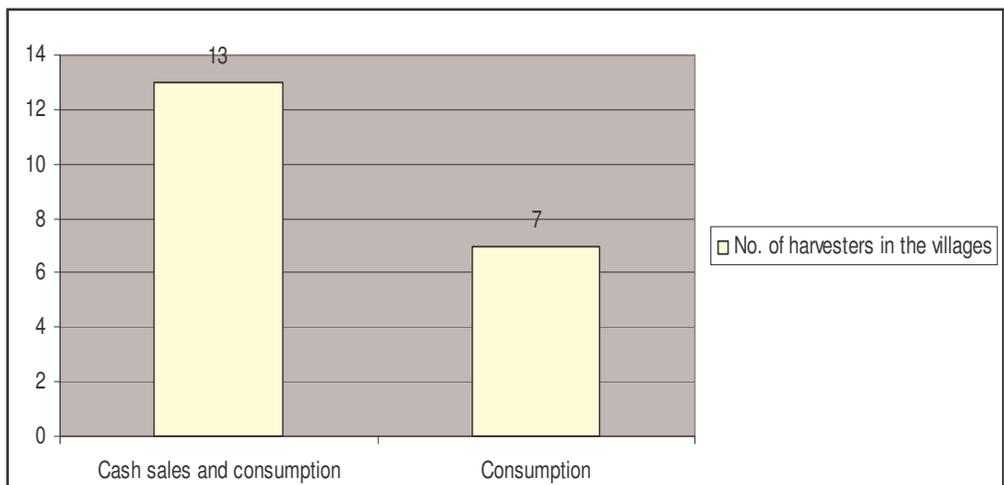


Figure 4.4 Reasons for harvesting mopane worms: Tamasane & Kgagodi villages.

4.4.1. Harvesting for Commercial Purposes

While mopane worm harvesting was traditionally for subsistence purposes, undertaken mainly for nutritional purposes, increasing commercialisation of the resource has been taking place throughout the mopane area in southern Africa in recent years (Hobane, 1994, and Kozaniya and Frost, 2002). More than 75% of the harvesters in informal settlements in Tamsane-Kgagodi area harvested the worms specifically for cash sales and consumption. 13% of informal settlers harvested strictly for monetary benefits while only 3% engaged in bartering. In the villages (Figure 4.4), 65% of harvesters, compared to 75% of harvesters in informal settlements, harvested for consumption and commercial purposes. Trading in mopane worms accounts for a large proportion in both groups of the harvesters (Table 4.7). 80-90% of mopane worms collected by informal settlements harvesters are used for commercial purposes. The conclusion that can be reached from these findings is that harvesters in informal settlements are more profit-minded than those in the villages.

Table 4.7 Utilisation of Mopane Worms

	Informal settlements	Harvesters in Tamsane and Kgagodi Villages
How much of mopane worms stock goes into trading (cash sales & barter exchange)?	80- 90%	50-70%
How much of mopane worms stock is for consumption at home?	10-20%	30-50%

Bartering is one of the modes through which harvesters trade in mopane worms. Some harvesters revealed that they have used mopane worms for bartering, but this is infrequent. They exchanged the worms for household goods such as kitchen utensils, bedding, and food stuff. They bartered with both *Batswana* and foreigners. One harvester revealed that she once bartered a 20l container of the worms for a standard blanket.

However, the number of those who engage in bartering is very minimal, as only 3% of the harvesters in informal settlements engage solely in bartering. Normally bartering is seen as an extra trade avenue, over and above other existing trade modes.

As to why many people want to cash in on this resource, the harvesters divulged crucial information that mopane worms are a resource that generates quick cash for rural families. They upheld the importance of mopane worms in their day-to-day lives, likening its importance to that of cattle. The harvesters disclosed that the profit they make from selling the worms is used to pay school fees for their children, over and above other uses. To emphasize how important mopane worms are, harvesters said statements like '*phane ke kgomo ya basadi*' and '*phane e bogadi bo gaufi*', meaning 'mopane worms are as important as cattle' and 'its easy to make quick cash with mopane worms'.

The harvesters revealed that a large number of mopane worm buyers come from both Botswana and South Africa. They further highlighted that most buyers in Botswana were middlemen who further sold the product to their South African fellow traders. A 25l container of mopane worms is sold for P100 (US\$ 16). The monetary benefits the harvesters get from selling mopane worms range between P500-P2500 per harvest season. But exactly how much one makes from their catch is based on the negotiations between harvesters and the buyers as there is no standard price.

Evidence of widespread utilization and exploitation of mopane worm resources across southern Africa for commercial purposes is growing (Hobane, 1995; Rebe, 1999; Gondo *et al.*, 2010). This is reported to have led to a decline in selective harvesting (Hobane, 1995). Rebe (1999) reported that commercialisation of mopane worms in southern Africa has led to over-harvesting with rural harvesters now collecting substantially more than a single person would have traditionally harvested for family consumption alone. Evident over-harvesting and increasing demands for mopane worms in South Africa has led to strong demands for imported worms from Botswana (Hobane, 1994, 1995; Moruakgomo, 1996; Kozaniya and Frost, 2002; Stack *et al.*, 2003). Hence the reports of the disappearance of the mopane moths and mopane worms from certain parts of Botswana after heavy harvesting (Bartlett, 1996; Illgner and Nel, 2000; Okezie *et al.*, 2010).

4.4.2 Harvesting for Consumption only

Mopane worms are seen as vital protein supplements in the diet of many rural poor communities. Traditionally mopane worms were harvested for nothing but household consumption (Ashipala *et al.*, 1996). However, this changed with the realisation that mopane worms were a resource that could yield economic benefits. Harvesting for consumption only is now history at least among the informal settlement harvesters in central Botswana (Figure 4.3). However it is not all doom and gloom as some harvesters in Tamasane and Kgagodi villages still harvest only for consumption. Generally harvesting for consumption is declining as many harvesters focus on drawing the economic and financial benefits from mopane worms.

4.5 Theme 3: Perceptions on the Impacts of Current Harvesting Practices on Mopane Worms and their Habitat

Harvesters in central Botswana identified both positive and negative impacts of their harvesting practices on mopane worms and their habitat. Mopane worms were reported to be decreasing in the area, and the harvesters identified two main possible causes: climatic factors and over-harvesting of the resource. This section discusses these aspects.

Human activities, especially harvesting practices, can influence prospects of sustainable use of NTFPs by impacting forests at various levels. Harvesting intensity and techniques may determine the magnitude of these impacts. For instance, if an NTFP becomes commercially valuable, levels of extraction can be determined and driven by market forces. Furthermore, increased demand for products can change the traditional low-impact patterns and techniques of resource extractions (Sinha and Bawa, 2001).

4.5.1. Positive and negative impacts of current harvesting practices on mopane worms and their habitat

The harvesting of NTFPs is particularly important for most rural communities in ensuring food security, maintaining the nutritional balance in people's diets, and providing a source of income (Ndangalasi *et al.*, 2006). However, excessive extraction of forest products, in this case mopane worms, is likely to impact negatively on the population dynamics of the resource being exploited, leading to changes in their sustainability and availability.

The harvesters were asked to identify impacts, either positive or negative; of the current harvesting trends on the mopane worms and mopane woodlands. The harvesters claimed that their practices were sustainable as they adhered to sustainable measures of harvesting such as:

- Avoiding cutting down of trees and tree branches during harvesting
- Avoiding clearing of trees during establishment of informal settlements. Some have opted to reuse the same camp site every year to avoid destruction of the worms' habitat.
- Evading unearthing of the worms that have already gone underground to pupate
- Leaving "the seed" as they called it, for further regeneration.

Participant observations revealed that most harvesters harvested mopane worms from trees that were within reach. Bending tree branches and picking from the ground were common practices among the collectors. No broken or cut tree branches were seen on the area and neither was equipment to speed harvest process seen in the camp site. Only a few, about ¼ of the harvesters used protective rubber gloves during harvesting and processing of the worms. Waste was well managed as most harvesters buried mopane waste on the ground. They claimed to have been advised by the Department of Waste management and Pollution Control (through Green Scorpions) to do so. No litter was

seen lying around. Also, mopane woodlands around the informal settlements were in high densities and still intact.

However, parallel to the previous studies, decline of mopane worms was observed in the study area. 36 harvesters out of 50 pointed out that there was evidence of fewer worms in the field since 2000 (Table 4.8).

Table 4.8 Evidence of less or more worms in the field since 2000?

MW status	Settlement 1	Settlement 2	Settlement 3	Tamasane	Kgagodi	Total
Less worms	4	4	12	8	8	36
More worms		2				2
Same	2	1	1			4
Don't know/undecided	1	2	1	2	2	8
Totals	7	9	14	10	10	50

The majority (72%) of the harvesters believed that the numbers of mopane worms were decreasing. Only 4% believed that mopane worms were increasing, while just 8% believed that there has not been any increase or decrease. 16% were undecided. The past three years were the worst in terms of the numbers of mopane worms in Tamasane-Kgagodi area in the past decade. Most harvesters highlighted that since 2007 until 2009, the outbreak and abundance of the mopane worms in the Tamsane-Kgagodi area has been very limited. They reported catching few worms in the first outbreak (i.e. December to January), and nothing in the second outbreak (April-May) during these years. Although the second outbreak of 2009 had not yet taken place, the harvesters anticipated a no worms-no harvest situation as the first outbreak was meagre.

4.5.2. Causes of the disappearance of mopane worms in the veldt.

The harvesters identified various causes for the decrease of mopane worms in the veldt which included climatic conditions and over-harvesting due to increased number of

harvesters (Table 4.9).

Table 4.9 Causes of the disappearance of mopane worms.

	Cause	No. of harvesters
a	Low, erratic and unreliable rainfall/Drought and high temperatures (Eggs and worms killed by very high temperatures)	25
b	Over harvesting caused by increased number of harvesters due to commercialisation of mopane worms	7
c	Both lower rainfall/drought and over-harvesting	2
d	Failure to obey the taboos <i>'MWs are supposed to be boiled and not roasted on embers'</i>	2

The harvesters highlighted that there was a decreasing number of mopane worms in the bush caused by poor and unreliable rainfall and drought. As they detailed, less and unreliable rainfall results in the sporadic outbreak of mopane worms, hence the congestion of people in these areas. This on its own way is unsustainable as people tend to 'glean' (collecting all the worms that are left behind) everything, likely to result in the decrease, or even the extinction of the worms in the concerned areas. This group of harvesters (group (a) in Table 4.9) totally de-linked the disappearance of the worms from human activities such unsustainable harvesting practices. The harvesters from Tamasane and Kgagodi revealed that in 2007, 2008 and 2009 mopane worms have been very few, to the extent that they did not have enough for household subsistence purposes. The harvesters blamed the shortage of rainfall as the cause of this situation. The harvesters also explained that ideally there may be two harvests in a year; the first harvest in December and the second harvest coincides with Easter at the end of March or beginning of April. However, while the December harvests yielded little, they have not had the

second harvest (April/May) for the past few years.

Extremely high temperatures were also blamed for the lessening of mopane worms. The harvesters argued that although they may have good rainfalls that lead to the laying of eggs by mopane emperor moth, extremely high temperatures in the Kgagodi-Tamasane area killed the eggs before they could hatch into worms.

A quick survey driving through the Mopane veldt in the harvest area revealed that few trees have been defoliated. Most trees were green without worms while quite few trees were stripped of all their leaves. Defoliation indicates a thriving mopane worm population (Toms and Thangwana, 2005). The sun was blistering hot, with accompanying high day temperatures, as high as 34°C. Only here and there were small pockets of fully developed worms observed. Small worms were observed hiding under tree leaves during a very hot day.

(a) Possible climatic causes of the decline in mopane worms

The main climatic factors that the harvesters identified as possibly causing a decline in mopane worms in central Botswana include low and unreliable rainfall and high temperatures.

Botswana is situated on the semi-arid fringes of Kalahari Desert. Rainfall varies from 700 mm in the North East and 250 mm in the South West while most areas receive between 300 mm and 500 mm on an average. The rainfall is generally low and unreliable and as a result, drought is present in the country one out of three years, (Holm and Morgan, 1985; Kruger and Grotzke, 2009). Particularly devastating are several droughts in succession (1981/2 and 1986/7) or droughts that are accompanied by high temperatures (Kruger and Grotzke, 2009). These do not only affect agricultural output but also affect the availability of some NTFPs like mopane worms (Stack *et al.*, 2003).

The first climatic factor that could be affecting the decline of mopane worms is rainfall. Mopane worms occur in summer, i.e. between December/January; and April/May. Rainfall and summer temperatures, especially day temperatures, are usually high in December and January, a time of first outbreak of the caterpillars. However this scenario

changes in April and May as rainfall amount is minimal in the study area while temperatures remain high (Figures 4.5; 4.6 and 4.7). This correlates with the information that the harvesters provided about the second season of harvest being meagre or not there at all in some years. Hence rainfall can be considered as one of the determinants of the availability of mopane worms; low rainfall means less worms, and vice versa. The availability of the worm relies on the amount and timing of rainfall and hence the vegetative production of mopane trees, relative to the hatching of its eggs from the emperor moth (Madibela *et al.*, 2007). As some studies reveal, low rainfall limits the abundance of the worms, since there is shortage of fresh mopane leaves on which they feed (Greyling *et al.*, 2001; FAO, 2009). The unpredictable nature of rainfall (could be late or early) in Botswana is thus likely to have a serious impact on the lifecycle of the worm, leading to reduction of the worms with time. For instance, 2008 was reported as a bad year in terms of the outbreak of mopane worms probably due to low rainfall, and this is likely so as low rainfall was recorded in the study area during that year (Figures 4.5 and 4.6). It is however interesting to discover that although the harvesters stated that 2007 was one of the worst years, the rainfall records indicate that it was a good year as it recorded the highest rainfall amount in a decade (1999-2008). The temperatures were also ideal (between 32°C and 20°C) for mopane worms to thrive. Evidently there were other hidden factors influencing this situation which require thorough investigation, such as the influence of low rainfall in the previous year (2006).

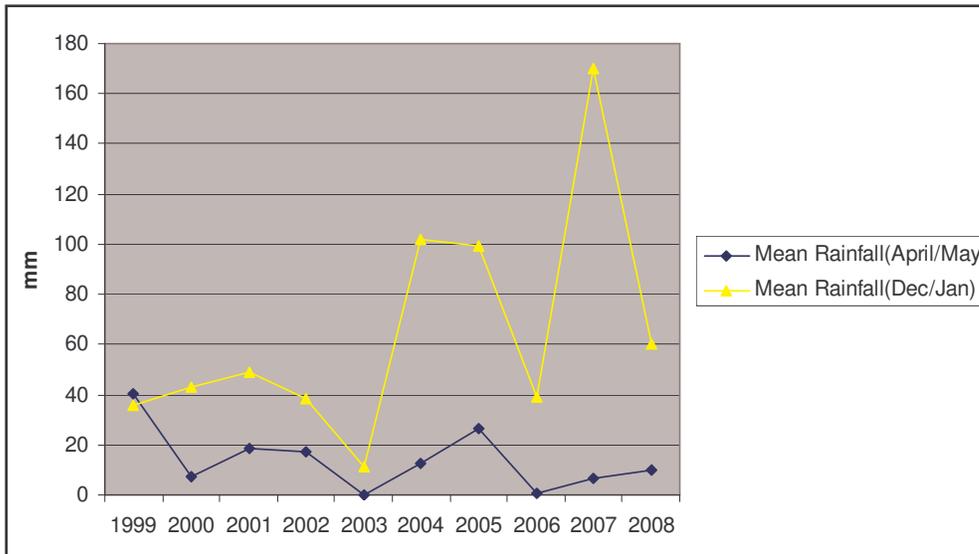


Figure 4.5 Mean rainfall for months in which mopane worms occur in Tamasane Village

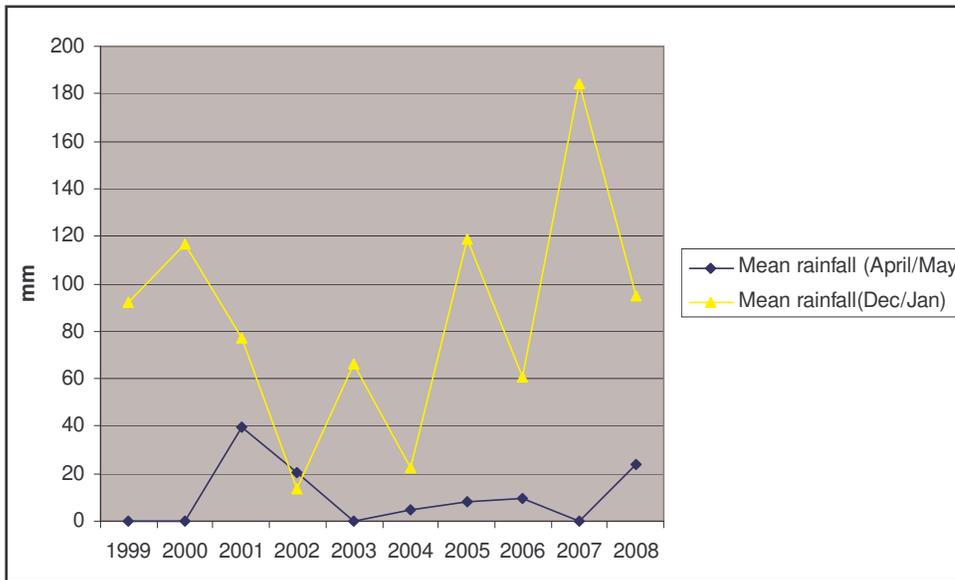


Figure 4.6 Mean rainfall for months in which mopane worms occur in Kgagodi Village

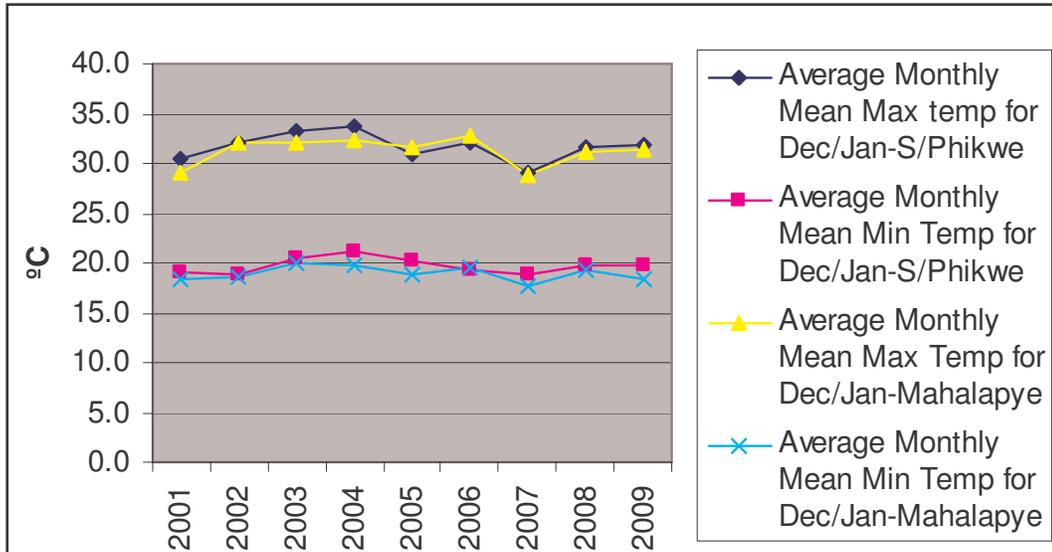


Figure 4.7 Maximum and Minimum average temperatures for Mahalapye and Selebi Phikwe townships (areas surrounding the study area)

The second climatic factor that could be causing the decline in mopane worms is high temperatures. The growth in caterpillars is strongly temperature dependent although the relationship between growth and temperatures varies between species (Taylor, 1981). Mopane worms occur in summer, a time at which temperatures are soaring high (Figure 4.7). Dry spells between rainfall events and high rates of moisture loss due to high temperatures are likely to affect the appearance of mopane worms. As the informants had observed, eggs laid by the moth often die before they could be hatched due to very high temperatures. This has not been proved by any research, and thus remains an area to be studied in the future. However, a study in Plumtree in Zimbabwe revealed that out of 4200 eggs obtained from wild stock, only 2297 hatched. The study nevertheless associated egg mortality with parasitism and infertility instead of high temperatures (Stack and Ghazoul, 2002). Another study was conducted on how the worms react to high temperatures revealed that during the hottest hours of the day the largest instar caterpillars or worms stop feeding and hang from the leaves. The caterpillars that displayed the hanging behaviour had higher body temperatures than those that were not. Smaller caterpillars on the other hand spend most of the time under the surface of the

leaves rather than on the stems (Frears *et al.*, 1997). The mean proportion of worms hanging in the laboratory was extremely low (<0.02) at temperatures of 35°C and below but increased rapidly to approximately 0.3 at 40°C. Similarly, in the field hanging behaviour was not apparent at ambient (shade) temperatures of less than 32°C but occurred frequently at temperatures greater than this (Frears *et al.*, 1997). This is likely to affect the feeding patterns and growth of the worms, pupation stage, and ultimately the lifecycle, although the study does not show how these important stages are affected. However, in the case of the Tamasane-Kgagodi area, the temperatures range between 20 °C and 34 °C, thus not posing any danger to the development of mopane worms.

Climatic factors play a significant role in the availability of mopane worms. In the Kruger National Park in South Africa dried out remains of small mopane worms were seen lying thickly under mopane trees and shrubs due to lack of rainfall and very high day temperatures. Only here and there were small pockets of fully developed worms observed. This adversely affected the second harvest in March/April as there were no worms at all despite the good rains (Toms and Thagwana, 2005). These observations show that even with minimal harvesting in a protected area, there may be a mopane worm crop failure induced by adverse climatic conditions. However, in the case of Botswana, it is likely that in addition to the climatic factors, there are factors contributing to the decline of the worms, such as over-harvesting.

(b) Over-harvesting of mopane worms

As some studies pointed out, mopane worms face a threat of being overexploited (Toms and Thangwane, 2005; Ghazoul, 2006; Harcourt, 2009; Yen, 2009). Commercialization of mopane worms results in over-harvesting of the worms, which ultimately leads to the reduction of the worms in the field. The economic hardships, burgeoning of mopane worm markets, and the change in urban diets have led to the commercialization of this resource, resulting in its use going beyond that of the subsistence level. Over-harvesting is also exacerbated by patchy distribution and highly eruptive nature of the worms due to climate-related factors and other factors. This situation produces a vicious cycle as

factors have a causal effect on each other (Arntzen and Fidzani, 1998).

According to the interview respondents the number of mopane worm harvesters has been increasing over the years. There are possible causes of this increase such as the effects of HIV/AIDS which removes the income earners from households. Other reasons might include global economic downturn, as reported in other studies.

Only twenty one percent of the harvesters related the lessening of mopane worms to over-harvesting (Figure 4.9). This group claimed that unsustainable harvesting practices such collection of immature worms, heavy harvesting that included collection of the 'seed', as well as overcrowding in the outbreak areas; were the main causes of over-harvesting. They affirmed that excessive harvesting interrupted the life-cycle of mopane worms, hence the reduction. While this group blamed over-harvesting only, another group (c in Table 4.9) which constitutes just 7% of the total percentage of the harvesters that attest to the declining of mopane worms combined this factor with low rainfall/drought. 'Over harvesting and low rainfalls' and 'failure to obey taboos' were the least popular causes identified by the harvesters.

Interestingly, when identifying the causes of the disappearance of mopane worms, the harvesters did not identify the use of unsustainable harvesting techniques, especially current techniques, as a cause. These findings were altogether unexpected. However, motivations for harvesting, especially harvesting for commercial reasons, and the climatic factors, were identified as the main causes of the disappearance of mopane worms in central Botswana.

5. Conclusion and recommendations

5.1 Key Findings Summary

The harvesting of mopane worms is one of the most important livelihood activities that rural people in central Botswana engage in due to the food security and income earning opportunities that it offers. The study revealed that mopane worm harvesters in central Botswana still use traditional harvesting practices such as bending tree branches, shaking trees and collecting from the ground. There were no modern technologies that harvesters used during the harvest except the use of rubber gloves to protect hands from the sharp spikes of the worms. These findings add to the studies conducted in the same area that revealed the same scenario (Stack *et al.*, 2003; Gullan *et al.*, 2005; Madibela *et al.*, 2008). However, some studies found out that the breaking of tree branches, the felling of trees and the digging of worms that have burrowed is becoming quite common in some areas in southern Africa (Greyling *et al.*, 2001; Gondo *et al.*, 2010).

The study found that the informal settlements were mostly made from tree branches and plastic covers. The findings reveal that harvesters prefer informal settlements to commuting in order to speed up the harvesting process and also to cut unnecessary costs. This phenomenon was alluded to by Stack *et al.* (2003) in passing but has not yet been thoroughly investigated. There are many issues that require investigation such as environmental and ecological impacts of informal settlements.

Harvesting mopane worms for subsistence use has shifted to harvesting for commercial purposes. This was confirmed by mopane worm harvesters in Tamasane-Kgagodi area in central Botswana. Mopane worms are harvested from communal woodlands, enhancing good returns from trading in the product. Various harvesting practices, both traditional and current, are used by the harvesters. The current practices were defined through this research and include much of the same techniques for collection of the worms but with less consideration of taboos and more use of informal settlements that maximise collection time, lower travel costs and give immediate access to the roadside market. The

current harvesting practices are generally thought to be sustainable as there is not much difference between these and the traditional ones although the increasing number of people engaging in harvesting can cause these practices to become unsustainable. However, if considering the current decrease on the worm population a shift of ‘spotlight’ from harvesting practices to climatic factors is needed, as these were highlighted by the harvesters as the key concern.

Interesting, however, is the discovery that although climatic factors are likely to have serious implications on the availability of mopane worms, harvesters motivations for harvesting may have a significant role in the lessening of mopane worms in central Botswana. Motivations for harvesting mopane worms have changed with time as harvesters have shifted from subsistence to commercial harvesting due to increased mopane worm market demands (Gullan and Cranston, 2010). According to the respondents of this research commercialisation has attracted more and inexperienced harvesters and resulted in over-harvesting of the resource in central Botswana. This resonates with other studies that also revealed that the commercialisation of mopane worms and ever growing demand for mopane worms have led to over harvesting of the resources in certain parts of southern Africa (Rebe, 1999; Stack *et al.*, 2003; Akpalu, 2007; Mutanga 2009; Gondo *et al.*, 2010). It is in this light that this study speculates that the disappearance of mopane worms in central Botswana is not due to unsustainable harvesting practices such as breaking of tree branches (as some studies have reported), but rather likely due to over-harvesting influenced by commercialisation of mopane worms, and the sporadic outbreak of the worms across mopane woodlands due to harsh climatic factors. However, considering the limitation of the study design, this may be proven untrue with further research.

5.2 Limitations of the Study

This research had certain limitations that need to be taken into account when considering the results and their contributions.

The study depended mainly on the information provided by the respondents during the administration of semi-structured interviews and simple visual observations. Both these sources are subjective and therefore introduce certain biases. This has influenced the results of the study in that the findings could not prove whether informal settlements had or had not impacted on the mopane woodlands and mopane worms. Also it could not be proven whether the lessening of mopane worms in central Botswana was due to the indirect influence of mopane worm commercialisation, but it did not show that it is necessarily due to unsustainable harvesting practices such as breaking of tree branches. Time and resource constraints limited the extent of data collection. The researcher had to do observations and administer questionnaires within a short period of time (Mid November and whole of December 2009) before the harvesters dispersed to their respective places of origin. The study could have been improved if it was conducted over a period of three years (minimum) to monitor the number of harvesters to find out whether it was increasing or not. Moreover, rather than the subjective visual estimates of damage, measuring the quantities of mopane worms and the size class structure and damage levels to mopane plants in plots where harvesters had collected the mopane worms would have greatly strengthened the findings of the study. The estimates of quantities of mopane worms harvested would have given the claims of over-exploitation credibility. Future studies could explore these areas for further research on the evolution of the harvesting practices of mopane worms in Botswana.

5.3 Recommendations

The harvesting practices of mopane worms in central Botswana are still traditional in nature. Further investigations are necessary to understand why there have not been any intense technological developments in the harvest of mopane worms despite increased trading in mopane worms that has become trans-border in nature. Experiments on the domestication of mopane worm farming have been conducted (Hope *et al.*, 2009) but they still lack an application/practical aspect since domestication is a costly process. However, knowledge gained in experimental domestication trials is also potentially useful to efforts to optimise the wild crop (Toms *et al.*, 2003). Furthermore, assessing market-chain analysis and value-addition, would assist in understanding this phenomenon better (Stack *et al.*, 2003).

Recolonisation of mopane worms in areas that were once rich in mopane worms should be considered as one other way through which the problem of decline in mopane worms can be addressed. Although this works more effectively on private-owned land rather than on communal land (Toms and Thangwana, 2005), collaboration with communities would be required to ensure the caterpillars are not harvested for a set number of years. This would allow mopane worms to adequately repopulate the area, to create a sustainable harvest in the future.

Consideration of indigenous knowledge systems, as supplementary to contemporary/scientific knowledge, is likely to greatly enhance the sustainable management of mopane worms. Over and above taboos that regulated the behaviour, harvesters showed that they had knowledge about the life-cycle of the worms, and how this cycle could be affected if certain unsustainable harvesting behaviour is displayed by the harvesters. If this could be tapped into, and be mainstreamed into current resource management policies, indigenous knowledge systems could enhance sustainable harvesting of mopane worms.

Environmental issues resulting from establishment of informal settlements in mopane worms' outbreak sites have to be looked into. Issues such as lack of sanitation facilities, lack of waste disposal facilities, drinking water quality and dangers/threats that harvesters are faced with and ecological impacts on the mopane woodland have not been researched. Greater understanding of the complex issues surrounding camping during mopane worm harvesting is especially important given the fact that their proliferation over time is becoming quite common in Botswana.

The management of NTFPs is very important for their availability tomorrow. The government of Botswana through the Department of Forestry and Range Resources is committed to regulating the harvest of mopane worms by developing regulations on the utilization of veldt products. Harvesters are required to apply for a permit to harvest the worms. Dealing in or exporting of mopane worms without a permit is prohibited. The issue of permits for harvesting and trading in mopane worms began in 2006, however, it was waived in 2008 when the Cabinet argued that it would adversely affect the livelihoods of rural households who depend on the product. This makes it difficult for the relevant department to successfully monitor the number of harvesters in the field, hence possibility of over-harvesting and disappearance of mopane worms in some areas due to increased number of harvesters. Perhaps issuing of quotas annually would be more effective, provided the harvesters understand the restrictions of the resources.

Finally, addressing poverty and food security issues in Botswana is critical in addressing the problem of over-harvesting of mopane worms. As already shown, non timber forest products play a significant role in the livelihoods of the rural poor (Warner, *et al.*, 2008). In the case of Botswana, there are far too few formal government initiatives for poverty alleviation based on natural resource use, or building on existing initiatives and trade networks of local communities. The difficulty of achieving a balance between improving livelihoods of the poor rural households and sustainable use of forestry resources can be addressed by improving the framework conditions (property rights, institutional

arrangements) that govern the use of common property resources and by supporting communities to establish indigenous natural resource management systems. Moreover, responsible government departments should become less punitive and policing, but actively engage with rural communities in a participatory fashion through appropriately trained extension officers to foster harvesting of natural resources in a sustainable manner, and where trading of resources is involved, value addition should be investigated (Shackleton, 2009).

This study recommends that instead of a top-down approach, multi-party/co-management approaches in sustainable utilisation of mopane worms and mopane woodland are ideal. It has been observed that joint stewardship works best where the rights, powers and obligations of each party are clearly defined (Rusnak, 1997; Fraser *et al.*, 2006). Mopane worm harvesters and the government of Botswana should therefore strive for sustainable management of the resource by co-managing the utilisation of the resource. Also, the government should focus on developing programmes geared towards alleviating poverty through sustainable use of natural resources and desist from a carrot-and-stick approach in managing resources.

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Appendix A

Key Informants (Department of Forestry and Range Resources)

The questions serve to collect information about the evolution of harvesting practices of mopane worms and how the modern practices are destructive

1. Position of authority _____
2. Sex: female/Male
3. Age
 - 20-29
 - 30-39
 - 40+
4. what role does your organisation play concerning the harvesting and use of natural resources? _____

5. what traditional mopane worm harvesting practices is your organisation aware of? _____

6. what modern mopane worm harvesting practices is your organisation aware of? _____

7. can you explain why there is change in practices of harvesting mopane worms?_____

8. what are the impacts of modern harvesting practices?_____

Thank you for your time.

Appendix B

Semi-structured interview questions for mopane worm harvesters (Tamasane & Kgagodi harvesters)

Sex of respondent: _____

Age Category:

- 18-24
- 25-34
- 35-44
- 45+

Interviewer: _____

Date: _____

Village: _____

Issue/question/problem	Notes	Comments
How long have you been harvesting mopane worms? <ul style="list-style-type: none">• Less than 5 years• 10-20 yrs• 20+ yrs		
Traditional harvest practices of mopane worms		
Current harvest practices of mopane worms		
Causes of shift from traditional to current practices		

Which practices do you use? Why?

What are your perceptions on the current harvesting practices?

(If a long-term harvester) is there any evidence of more or less worms in the field since 2000?

(If there are fewer worms) what are the causes of the disappearance of mopane worms?

Appendix C

Mopane worm harvesters (Informal Settlements)

Sex of respondent:_____

Age Category:

- 18-24
- 25-34
- 35-44
- 45+

Interviewer:_____

Date:_____

No. of people in the family:_____

Informal Settlement No:_____ Source of income:_____

Issue/question/problem

Notes

Comments

How long have you been harvesting mopane worms?

- Less than 5 years
- 10-20 yrs
- 20+ yrs

Describe how you harvest mopane worms

Why do you harvest mopane worms

What is the advantage of staying in an informal settlement than at your home?

How long have you harvesting worms through establishing informal settlements in the breakout areas?

Traditional harvest practices of mopane worms

Current harvest practices of mopane worms

Which practices do you use and why?

Causes of shift from traditional to current practices

What are your perceptions on the current harvesting practices?

(If a long-term harvester) is there any evidence of more or less worms in the field since 2000?

(If there are fewer worms) what are the causes of the disappearance of mopane worms?
