BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF GEOSCIENCES

The contribution of Mopane Worms (*Gonimbrasia belina*) as NTFP to rural communities in the wake of El Nino induced droughts as case of Ward 12 Beitbridge District Zimbabwe

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(B1440604)

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE MASTERS OF SCIENCE HONORS DEGREE IN NATURAL RESOURCES MANAGEMENT AND ENVIRONMENTAL SUSTAINABILITY

DECLARATION

I, Regis Isheanesu Mafuratidze, do hereby declare that this document is my original work that I have done. It has never been submitted or being concurrently submitted by any other individual in any other institution.

The undersigned confirm that they have read and recommended to the department of Geosciences, the thesis;

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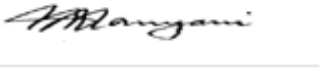
Chairperson… 

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Date……10/10/24……

Dedication

This dissertation is dedicated to myself for the time and effort put in to get a polished final product as it was not easy balancing work school and social life.

Acknowledgements

I am incredibly grateful to God for the power and strength to sail through the dissertation period. I express my gratitude to Dr. E. Siziba for his unwavering supervision during the project's duration. Additionally, I would like to thank Beitbridge Rural District Council for allowing me to conduct the research in one of its wards. In addition, I would want to thank my family, who have supported me much during my research journey. Special mention goes to Mr P Mafuratidze for his unwavering support from day one through the reviews and help in data collection and GIS.

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Abstract

The research sought to assess the contribution of Mopane worms *Imbresia belina* to rural communities during times of El Nino drought with emphasis on Ward 12 Beitbridge district. An inventory into the Mopane tree's distribution as a resource base for the mopane worms was carried out alongside the various processes, quantities and uses of the mopane worms in ward 12. The research sites were picked based on areas were the Mopane worms usually occur in the Ward. The sampling method of an Adaptive cluster was then used to sample the Mopane trees to support the NDVI desktop study which had been carried out to determine the distribution of the trees. Purposive sampling was used to select the respondents in the ward and a questionnaire was administered using the Kobo toolbox which had questions that related to the processes, quantities and the various benefits/uses of the Mopane worm in ward 12. The respondents in Ward 12 pointed out that they mainly used the plucking and picking method in their harvesting of the worms an on average in a good season they would harvest up to 220kg and in a bad season it would then go down to about 40kg. The main uses of the of the mopane worms that came from the respondents were consumption and trade though some of the respondents acknowledged that the mopane worms were also used as stock feed though they had not practiced it in their ward. Climate changed emerged as the leading risk to the existence of Mopane worms in the ward as longer dry spells like the recent one being caused by the El nino induced drought are destroying the resource base as well as destroying the eggs of the Mopane worms before they pupate. The various Stakeholders in Ward 12 were encouraged to plant more trees to cater for the lack of trees in the areas around the homesteads as it would go a long way in mitigating the devastating effects of climate change that they were presently facing. Value addition and beneficiation was also encouraged so that the community would realize more profits from the sales of the Mopane and they can store them for later use in times of drought.

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List of Acronyms

FAO- Food and Agriculture Organization

KII- Key Informant Interview

NDVI- Normalized Difference Vegetation Index

NGO- Non Governmental Organization

NIR- Near Infrared

NTFPs- Non-Timber Forest Products

SAFIRE- Southern Alliance For Indigenous Resources

WFP- World Food Program

UTM- Universal Transverse Mercator

Chapter 1: Introduction

1.1Background to the study

NTFPs that is non-timber forest products are widely used by many people worldwide, and over a billion people rely on forests for their survival (Chao, 2012). NTFPs are used frequently in less developed countries where a larger portion of the population directly depends on forests for their livelihood. It is estimated that more than two thirds of the 600 million people living in Africa depend on non-timber forest products (NTFPs) for either monetary revenue or survival (Arnold 2001; Sunderland et al, 2003). Forest related sectors employs in excess of 15 million people in Southern Africa, which include small-scale sawmilling, commercial hunting, the production of handicrafts, and the sale of firewood and charcoal (Kaimowitz, 2003). Non-timber forest products are gathered regularly or as a backup plan in times of need, for both commercial and sustenance purposes (Kaimowitz, 2003). They may also have significant cultural meaning and value, and they increase people's security of livelihood. According to Sunderland et al, (2003), NTFPs comprise an array of forest produce, such as mushroom, resins, roots, bark, leaves, flowers, tubers and firewood. The role of the Mopane worm (Gonimbrasia belina) as an NTFP will be evaluated in this study. Mopane worms are abundantly found in Mopane woodlands (*Colophospermum mopane)* which is widespread in Sub-Saharan Africa and some areas of India (Melusi and Mojeremane 2012).

Mopane forests, which are common in Southern Africa and some semi-arid regions of India, are home to an abundance of mopane worms (Melusi and Mojeremane 2012). A wide area stretching from regions in the north of South Africa into Zimbabwe, into Northern Namibia and Botswana which is home to the massive outbreak populations of mopane forests, which are the plant host of mopane worms (Stack et al, 2003). Most of these locations are located in areas where raising livestock is the most suited kind of agriculture due to the risk involved in farming (Stack et al 2003). Mopane woods in Zimbabwe extends from Tsholotsho in the northwest, Chiredzi, Mwenezi, and Plumtree, Matobo, Gwanda,Mangwe and Beitbridge in the south (Gondo et al, 2010).

Each year, mopane moths produce two cycles first in October–November the second in February–March. A month later, the larvae are frequently seen in great quantities (Gondo et al 2010). As

cited by Sekonya et al, (2020), mopane worms are a valuable source of protein and provide a substantial contribution to rural communities in making sure they are food secure. Gondo et al, (2010) notes that collectors gather clean, dry mopane worms for commerce and domestic usage throughout the outbreak season. The mopane worm's commercialization is a crucial rural livelihood strategy that gives people a significant source of revenue (Kozanayi and Frost 2002). The harvesters subsequently spend these earnings on home supplies, medical expenses, and school tuition (Thomas 2013).

In recent years, the Mopane worms have helped the rural populations immensely to counter the effects of droughts episodes which are El Niño induced through falling back on the NTFP as a source of income through trade and a dietary supplement (Makhado et al. 2009). El Nino is a complex meteorological phenomenon that has recently impacted numerous countries across the world. According to CRS, (2016) El Nino is defined by strangely warm water temperatures in the equatorial Pacific. El Nino has had a major impact on global weather, causing drought in some regions and excessive rainfall in others. El Nino had an impact on a large portion of Indonesia, especially in Nusa Teggara, where dry conditions were reported, resulting in fires and the drying up of water supplies (WFP, 2016). El Niño resulted in a significant crop failure in South Sudan because of the region's poor rainfall, which affected crops like vegetables, groundnuts, and maize (WFP, 2016). Due to a scarcity of water and feed, animal deaths were rampant, and pastoralists relocated into non-traditional dry-season locations, escalating tensions amongst communities (Catholic Relief Services, 2016). El Nino caused insufficient and delayed rains in Zimbabwe, which led to late planting and withered crops. Foot-and-mouth disease outbreaks significantly weakened the coping mechanisms of herding households, and livestock body conditions worsened as a result of shortages of feed and water (WFP, 2016). Food insecurity was made worse by the drought that affected livelihoods in the southern provinces of the nation (FAO, 2016). As a result of the drought, approximately four million people, or around 40% of the countryside community, experienced food scarcity at the height of the dry season (FAO, 2016). This issue has also affected Zimbabwe in the 2023–2024 season, as evidenced by the prolonged dry spells and poor rainfall patterns that have plagued the country's rural areas (Mugiyo et al. 2023) This climatic phenomena makes it imperative to conduct research on the quantity of mopane trees (which serve as the plant hosts for mopane worms) and the role that mopane worms play in rural communities, primarily as a safety net and fall-back during El Nino-caused droughts.

1.2 Problem Statement

The majority of Zimbabweans, particularly those living in rural communities, rely on agriculture for their existence since the country's economy is based primarily on agriculture. However, smallholder farmers who largely relied on rain-fed agricultural production have been impacted by events, such as El Nino-caused drought, leading to food shortages (WFP, 2016), and this is also further supported by a document on El Niño's Impact on Agriculture in Southern Africa in 2023–2024 which forecasted low rainfall patterns and longer dry spells to be experienced in the country throughout the season due to El Niño (Mugiyo et al. 2023). El Nino caused a prolonged arid spell in Zimbabwe and other African countries that is, the worst experienced in 35 years, (FAO, 2016). Due to this phenomenon, which primarily affects rural populations, they must rely on NTFPs for food and income (FAO, 2016) (Sekonya et al. 2020). There is a lack of comprehensive assessment and documentation of the abundance of the resource base and the uses of Mopane worms in El Nino-induced drought. In light of this, an inventory of mopane trees used as a mopane worm resource base and an evaluation of the mopane worms' relative contribution to rural populations during the El Niño-induced drought in Ward 12 Beitbridge district were conducted in this study.

1.3 Aim

- To assess the contribution of Mopane Worm (*Gonimbrasia belina*) as NTFP to rural communities in the wake of Elnino induced droughts in Ward 12 Beitbridge District Zimbabwe

1.4 Objective

Specific objectives

- To identify the spatial distribution of Mopane tree populations as resource base for Mopane worm
- To determine the processes and quantities of harvested Mopane worms
- To investigate on the benefits of Mopane worm in ward 12

1.5 Research justification

The study's findings will contribute to the information needed to develop mopane worm conservation and management plans. The study's findings will also assist the community in coming up with better choices on the use of mopane worms during El Nino-induced droughts. The study findings would assist the natural resource committees in the ward by creating bylaws that support preservation as well as governed use of mopane trees. The research's findings would assist the Zimbabwean government and other interested parties in increasing the number of jobs in the forest by commercializing these Mopane worms. In order to maximize the benefits of the mopane worms for the locals, non-governmental organizations (NGOs) that collaborate with different Beitbridge villages will also find use in the research findings about the resource base as they lobby for value addition and the product value chain beneficiation.

1.6 Limitations of the study

Language barrier was one of the challenges that the researcher encountered during the study as the study community was Venda. A translator was then used to alleviate this issue, albeit it is noted that this kind of communication may not be as effective as it may be because some information may not be conveyed accurately. Budgetary restrictions resulted in a somewhat small sample size, and the ward's covered regions.

1.7 Delimitation of the study

The research was done out in the rural community of Makhado ninety-five kilometres from Beitbridge along the Bulawayo-Beitbridge highway. The study was done in May supposedly the time after the second outbreak season of the mopane worms. Thirty-five respondents were chosen for the study with collectors and traders of the mopane worms being picked using purposive sampling. The survey was conducted in the period of school hours, and adult men and women were questioned while the kids were in class. Because of accessibility concerns, the data was gathered near the main road.

CHAPTER 2: LITERATURE REVIEW

2.1 Mopane tree spatial distribution

Within the sub-tropical regions of Southern Africa's savannah ecosystems, the mopane tree, scientifically known as Colophospermum mopane, is a dominating leguminous tree with large leaves like butterflies. It is a member of the Caesalpinioideae sub-family (Pokhriyal et al., 1990). It falls between latitude latitudes 9° S and 25° covering regions of Botswana, Zimbabwe, Mozambique, Namibia, Malawi, Zambia, Angola, Malawi and South Africa (Makhado et al, 2018). According to Mapaure (1994), mopane woodlands make up between 30% and 35% of the 1.5 million km2 of savannahs in southern Africa, which is more than a quarter of the region's total land area. According to Chidumayo and Sawadogo (2010), Colophospermum mopane is found in the arid valley ends of south of Angola, north of Namibia, central and south of Mozambique. It also crosses Botswana and Zimbabwe. Research has verified that soil types, height, and rainfall (Makhado et al, 2014) influence the spread of mopane in Southern Africa. Mopane trees are found in regions with low to moderate rainfall, 400–800 mm per year, typically 200–600 m above sea level, and varying soil types, including sandy, loam, and clay (Makhado et al, 2014). Another element that affects mopane tree distribution is temperature, as these trees are typically found in warm climates, particularly in their southern range (Sekonya, 2016). In Zimbabwe, mopane woods are found under a range of land tenure and access configurations. They can be found on state farms, large-scale commercial farms, communal grazing areas, and homesteads (Stack et al, 2003). Mopane woodlands in Zimbabwe, can be found along an arc that stretches from Tsholotsho in the northwest to Chiredzi and Mwenezi to the lower Save Valley in the east, via Plumtree, Matobo, Mangwe, Gwanda, and Beitbridge in the south (Gondo et al, 2010). Mopane worms in this region produce two generations annually: the first in November- December and the second in March-April. A month later, larvae are frequently found in considerable quantities (Gondo et al, 2010). Although they are not as extensive as they are in southern part of Zimbabwe, mopane trees and worms can also be found in the Zambezi Valley (Gondo et al., 2010).

2.2 Mopane worms Harvesting techniques and Quantities

2.2.1 The Mopane worm

According to Dube & Dube (2010) and FAO/WUR (2013), the mopane worm, scientifically known as *Gonimbrasia belina*, is one of the most well-liked and profitable caterpillars on the African continent and because it mostly feeds on and thrives on mopane trees, it is known by the term "mopane worm" (Dube & Dube, 2010).

Figure 1 Adult mopane worm photo cred observation.org/photos

Comprehending the mopane worm's life cycle is crucial in order to identify its weak point, which could potentially affect the ecosystem as a whole (Maviya & Gumbo, 2005). When the rainy season start, from end of October into November the mopane trees sprout fresh leaves, mopane moths emerge and lay their eggs on the mopane trees leaves (Maviya & Gumbo, 2005). The season ends when the larvae pupate, having gone through five instar stages before being harvested in December/January and April/May (Ditlhogo et al. 1996).

After a few weeks, the eggs hatch into tiny caterpillars known as ubiro, which are not harvested for human consumption but are occasionally moved to places close to homesteads so that the mopane worms can be harvested later (Maviya & Gumbo, 2005). Before reaching their maximum size, the new-born caterpillars flutter four times, as they grow; nourishing on the leaves of the mopane, trees (Oberprieler, 1995). Harvesting time begins six weeks after caterpillars multiply to a breadth of 2 cm and a length of 6 to 8 cm (Maviya & Gumbo, 2005). After that, the worms will descend the tree to hide in the ground. Those that make it to the ground will pupate to become moths during the following mopane worm season (Maviya & Gumbo, 2005). The majority of mopane worms in Botswana are collected in tribal regions where anyone is permitted to do so by local legislation (Stack et al, 2003). Numerous researches conducted in Zimbabwe revealed that mopane worms are collected from diverse locations. For example, people of Kapeni village only 92% collected mopane worms within the vicinity of their homes and 8% collected from the grazing area of the community. (Frost and Gondo, 2003). In areas around Mwenezi, Chivi and Mberengwa districts widespread outbreaks of mopane worms take place on mopane woodlands in commercial farms attracting villagers from surrounding communal areas and outsiders (Stack et al, 2003). A further research done in Chilonga area of Chiredzi revealed that almost 75% of the total harvest was dependent on outbreaks of mopane worms from state forest woods (Epungeni Forest) by the local population (Stack et al, 2003)

2.2.2 Harvesting processes and quanties of Mopane worms

According to Makhado et al (2014), the outbreaks for mopane worms happen twice a season, the first time one beginning in December- January and the next one being around April to May. Typically, the mopane worms are harvested from trees and the ground when they are in the last stages of their life cycle, which is the fifth instar (Stack et al, 2003). For those mopane worms that are removed from the earth before they pupate they typically have less food in their bellies, making them simpler to handle (Stack et al, 2003). In order to eliminate all undigested material from the gut, majority of the worms are gathered from the trees while they are feeding, and a comprehensive processing procedure must be performed (Gondo and Frost, 2002). Traditionally, mopane worms are collected six weeks after the eggs hatch on the ground, or they can be taken from reaching tree branches that are 1.5 to 1.8 meters above the ground (Hobane, 1998). When mopane worms are mature enough to be harvested, they typically measure around 2 cm in diameter, or human thump size, and the local government must approve the harvesting process before it can begin (Maviya

& Gumbo, 2005).To determine whether a caterpillar is present, people typically look for waste products beneath mopane trees (Stack et al, 2003). Collection and processing of mopane worms is still mostly done the old-fashioned way across the mopane belt, however widespread tree destruction to optimize collection is becoming recognized as a problem (SAFIRE, 2002). By grasping the mopane worm by its head or tail and dragging it away from the branch, one can easily break the tension applied by the suction pads on its legs and separate it from the tree (Taylor, 2003). Every year, depending on the rainfall experienced during the season, Botswana receives two harvests of mopane worms (IIgner and Nel, 2000). First one occurs in December to early January, and the second, takes place in April to early May (Hope et al., 2009; Madibela et al., 2009). People visit the epidemic areas throughout the harvest season, and some establish temporary, unofficial shelters there in order to collect worms (Stack et al, 2003). Women and children do a significant job in the mopane worm collecting and processing supply chain, with men mostly serving as middlemen between the harvesters and markets (Ghazoul, 2006). According to research done in Botswana, the mopane belt is situated in common places where harvesting is allowed by custom (Stack et al, 2003). As cited by Stack et al, (2003), the demographics of the collectors in Botswana showed that seventy four percent of those who harvested mopane worms were adults of the ages of 21 and 60, eight percent were over sixty one, and fourteen percent were young people between the ages of eleven and twenty. Notably, 96% of these groups were women. Zimbabwe's severe economic conditions, including frequent droughts, high rates of unemployment, and swift inflation, have made it difficult for families to maintain themselves and forced men and women of all ages to harvest mopane worms (Stack et al, 2003). In addition to women, more men and young people are joining in the gathering, processing, and selling of mopane worms (Stack et al, 2003). Because mopane worm outbreaks are unpredictable, the quantities harvested fluctuate from year to year as well as within and between communities (Stack et al, 2003). There have been estimates that suggest a 4000 acre woodlot may feed 19 million mopane worms, or 193 tonnes of mopane worms in a season (Dube & Dube, 2010). According to Taylor (2003), harvesters in Botswana receive 2 to 4 20L containers of degutted worms per person during a productive harvest season. This results in up to 7 twenty-five kilogram sacks (350kg) of dried worms at the conclusion of the season.

An individual may only fill one bucket each day during a poor harvest season, in turn having at most three bags (75 kg) (Taylor, 2003). Research from South Africa indicates that the yearly collection and commercial trade of mopane worms amounts to roughly 16,000 metric tonnes (Potgieter et al, 2012). In Zimbabwe studies that have been carried out show that communities average mopane worm production ranged from 36kg– 217kgs per household per season (Stack et al, 2003) with highest averages coming from the communities which were adjacent to commercial farms for example in Gwerima Chivi district (Stack et al, 2003).

2.3 Benefits of the Mopane worm and their contribution to rural communities

There have been quite a number of uses of mopane worms that have been brought forward and their relative contribution to rural communities where most of these mopane worms are found. A study carried out in Giyani area of South Africa also shows that mopane worms are mostly collected for household sustenance as 72% of mopane worms have historically been collected by rural households for survival use, significantly contributing to rural diets; however, adequate assessment has been lacking to support this claim (Ashipala et al, 1996). As cited by Makhado et al (2014), the respondents in the study area acknowledged gathering worms for their nutritional supplement needs. Mopane worms have a significantly larger amount of protein, fat, and carbohydrates than those present in beef and chicken, thus their nutritional value should not be overlooked (Moreki et al, 2012). According to studies, mopane worms have between 48% and 65% protein, between 444 and 543 kcal/100g of calories, between 4 and 11 g/100g of minerals, between 11 and 14 g/100g of carbohydrates, and between 16% and 18% of fat (Kwiri et al, 2014). In the end, 100 g of dry mopane worms offers up to 76% of the day-to-day protein needed by an individual, along with other essential minerals and vitamins like iron, calcium and phosphorous (Potgeiter et al, 2012: Kwiri et al, 2014).

Trade has also been another major highlight on the uses of mopane worms across the board. The trade has been exacerbated by the rise in economic hardships which generally characterize the rural communities in the Sub-Saharan Africa where these mopane worms are abundant. Changes in weather patterns have also played a part with climate change taking a toll on the other livelihood strategies for the rural folks like agriculture which have been crippled leaving them with trading of NTFPs like mopane worms.

Through a variety of marketing networks, dried out mopane worms from countryside areas have made their way into both the recognized and unceremonious national markets (Frost and Kotsanyi, 2002 and Stack et al, 2002). The mopane worms have a lengthy marketing chain because they are sold in a wide range of locations, such as supermarkets, wholesalers, open markets, roadside vendors and tuck-shops. They are transported to town markets via a number of routes that is rural traders, collectors and urban middlemen (Stack et al, 2003). Mopane worms are a major source of revenue for many rural people and are traded on a profitable basis in South Africa, Botswana and Zimbabwe (Mpuchane et al., 2001). They also demonstrate a strong economic return.

According to studies in Namibia, 50-kilogram sack of with mopane worms was selling for R715 (Thomas, 2013). According to research done in South Africa, an 80 kilogram bag of mopane worms made of maize meal cost between R752 to R1002 in 2005 (Makhado et al, 2014). A different perspective on the trade has been provided by additional research conducted in South Africa, which also shows 1 kg of mopane worm going for between R50 and R80. This suggests that the trade of 16 000 metric tonnes of mopane worm, which is the average amount harvested annually per season, can bring in between US$39 million and US$59 million (Potgieter et al, 2012). Mopane worms are gathered for both economic and subsistence needs in Botswana (Stack et al., 2003). Many rural residents of Botswana can find seasonal work in the mopane worm industry (Mphuchane et al., 2000). In Botswana, a 32 kg bag of mopane worms cost US$1.15 when purchased in metropolitan areas. According to studies done in Zimbabwe, mopane worms sold for roughly US$0.33, US$0.42, and US$0.56 per kg, respectively, at rural marketplaces including Bubi, Rutenga Business Centre, and Mwenezi. These prices were somewhat less than those in the region. (Makhado et al, 2014). Moving on to metropolitan marketplaces, the mopane worms sold for US$0.96 per kg in towns like Masvingo, whereas in large supermarkets, the costs varied from US$0.62 to US$1.34 per kg (Makhado et al, 2014). It is therefore crucial to conduct a study to find out if the mopane worms are still fetching the same prices in light of the current developments of the El Niño-induced droughts due to the swings in pricing and valuation. Another kind of trade that was popularized was bartering, where mopane worms were traded for goods that the harvesters would not otherwise have access to, particularly in Zimbabwe's rural areas (Stack et al., 2003).

In order to complement what they lacked, households traded mopane worms for other items like clothing, food grains, and kitchen equipment; typically, these exchanges took place within the

neighbourhood (Musitini, 2002: Stack et al, 2003). A good example would be Chiredzi, where the homestead accounted for 65% of barter trade transactions, local centres for 24%, and the Mopane woodland for 10% (Musitini, 2002). Mopane worms has also been employed as animal feed in other locations (Mpuchane et al., 2000). Due to its outstanding nutritional value, a number of authors attest to the rapidly growing interest in mopane worms as an animal food source in the near future (Kwiri et al., 2014). Mopane worms have nutrients that are good for animal health, including proteins, lipids, fatty acids, vital amino acids, minerals, and carbohydrates (Moyo et al, 2019). The mopane worm has been shown to be a useful source of protein for reducing undernourishment in fish and poultry. It has also been utilized as animal feed for guinea pigs, fish, broilers and layers (Moyo et al, 2019). Research conducted in South Africa and Botswana indicates that mopane worms are likely a source of protein for livestock diets. According to reports, the primary purpose of mopane worms supplied from Botswana in to South Africa is for cattle feed (Mpuchane et al., 2000). Rural households rely heavily on the commercialization and trade of mopane worms as a source of revenue (Kozanayi and Frost 2002). The harvesters utilize the money they get from selling mopane worms to pay for home supplies, medical expenses, and school fees, demonstrating how the revenue from this trade greatly influences the lives of those living in rural areas (Thomas 2013). Mopane worm trading protects households against unforeseen food or income shortfalls brought on by drought, illness, or other unforeseen occurrences by compensating for seasonal limitations in cash or food (Gondo et al., 2010). Mopane worm earnings can be used to invest in a variety of businesses, such as acquiring more stocks or constructing other home improvements, to enhance the family's standard of living (Gondo et al, 2010). According to Stack et al. (2003), in Botswana the proceeds from the sale of mopane worms are typically utilized for a variety of expenses, including the purchase of food, grains, kitchenware, school supplies, medical costs, and travel. According to Gondo et al. (2010), trade of mopane worms in rural communities in southern Zimbabwe may account for as much as 25% of a family's cash returns. This then depends on the amount of mopane worms collected during the season, the percentage that is sold, and the family other sources.

CHAPTER 3: METHODOLOGY

3.0 Materials and Methods

3.1 Study area and Target population

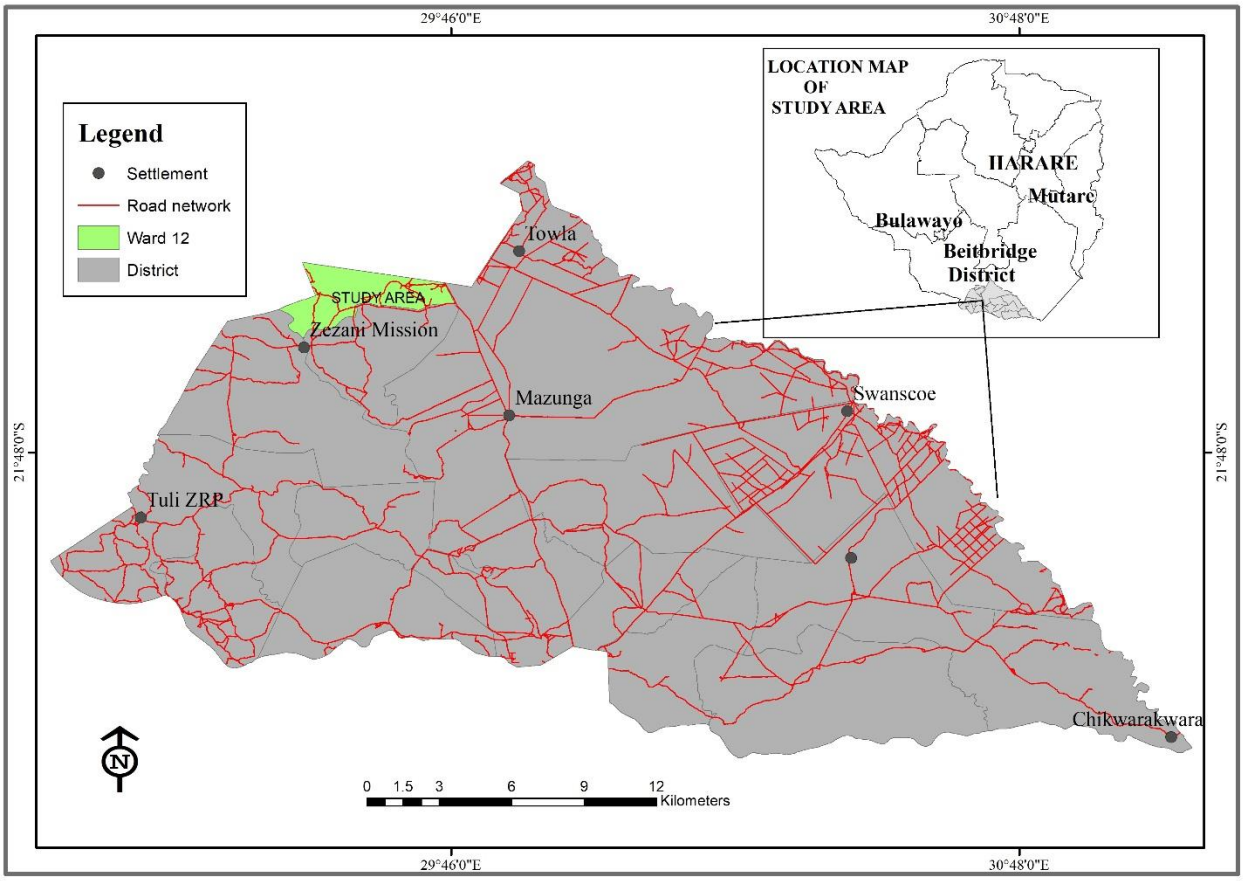

Figure 2 Beitbridge District Map

The research was done in Beitbridge district in Matabeleland South Province in Zimbabwe. The district falls under agro-ecological region 5, it has 15 wards with fifty eight villages and a total area coverage of 12 697 kilometers, with a total of 23 000 households. However, the study focused on ward 12 of Beitbridge district. Ward 12 lies 92 km out of Beitbridge town along the Beitbridge-Bulawayo highway in Makhado area. The ward has six villages namely Majini, Siyoka, Mpande, Madzive, Mtangamtshena and Vhutululla The area obtains an annual rainfall of 330mm to 380mm and is associated with high temperatures with a mean annual temperature of 23 degrees Celsius The residents of this ward largely depend on drought-resistant small grain crops and some non-timber forests products (NTFPs) to complement the small grains because of the local climate.

Adansonia digitata (baobab), *Colophospermum mopane* (mopane tree), and *Berchemia discolor* (Marula) are among the common tree species in the area (Matsa & Dzawanda, 2019).

3.2 Data collection methods

Data was collected within Ward 12 focusing on four villages namely; Siyoka, Majini, Mpande and Madzive. The research sites were designated based on the areas within the ward where the Mopane worms frequently occur. NDVI (Normalized Difference Vegetation Index) a remote sensing technique was used to collect data on the condition of the Mopane worms as a resource base of the Mopane worms The visible and near-infrared portions of the electromagnetic spectrum are utilized to calculate vegetation reflectance, which is used to quantify vegetation cover and growth status (Muthi'ah et al., 2023). The greater the NDVI range, according to Karaburun & Bhajari (2010), the lusher and healthier the vegetation. A mobile application tool UTM Geo map was employed to collect ground control points of the various mopane trees that were sampled in the ward for mapping the spatial distribution of the Mopane trees as a resources base. UTM was used because of its easy accessibility as it can be downloaded on mobile phone and can be used for free

Key Informant Interviews (KII) were done with the several government department that are key stakeholder in the exploitation of the Mopane worms in the ward which include the Beitbridge Rural District Council, Forestry Commission and some NGOs who have previously worked with the communities. The KII provided insights about Mopane worm's exploitation in the district. They also played a role in identifying sites where these Mopane trees and worms are found. Semi-structured interviews were also done with the harvesters, traders and consumers using a guided questionnaire on the Kobo toolbox platform were their various responses were recorded. Kobo toolbox was used due to its ease use as it stores a lot of data and responses are uploaded as the interviews take place which saves a lot of time during interview sessions with respondents.

3.3 Sampling techniques

To determine the spatial distribution of the *Colophospermum mopane* trees as a resources base to the *Imbresia belina* (mopane worms), adaptive cluster sampling method was used to sample the mopane trees. This approach minimizes effort in places where the target species are non-existent or only poorly inhabited, focusing mostly on samples of the species (Sullivan et al, 2008). The ward was organized into clusters based on the predominant locations of Mopane. In order to ground truth the data that had been gathered using the NDVI, 100m x 100m plots were then created in the

clusters. Following this, a recording exercise was conducted to account for the spatial distribution of the Mopane trees in the ward.

Purposive sampling was used to get, data on the varying quantities of Mopane worms harvested and their importance to rural populations, particularly during drought times. Purposive sampling is a non- probability sampling method that makes use of the researcher's decision in selecting the sample's elements (Saunders et al, 2012). A guided questionnaire template was used to collect information on the demographics, quantities, uses, threats, possible solutions and contribution of Mopane worms mainly in the drought periods.

3.4 Data Analysis

3.4.1 Spatial distribution of the Mopane trees

To determine the spatial distribution of the Mopane trees, NDVI which is a remote sensing method was employed to detect mopane trees in winter when most trees shade. In winter, mopane trees actually cast very little shade due to a unique adaptation for surviving in hot and dry environments as compared to other constituent tree species (Muthi'ah et al., 2023). The NDVI index mainly focuses on detecting health vegetation vigor using red and near infrared bands. The easy identification of vegetation using this index is contributed to high absorption of electromagnetic radiation in red band and a high reflectance in the NIR (REF) (Muthi'ah et al., 2023).

3.4.2 Mopane worm Quantities, Processes and Benefits

The data from the interview was transcripted manually into the Kobo toolbox during the interview sessions. Once all data had been captured and uploaded, it was arranged and sorted into different codes and themes determined by the topics and questions discussed during interviews. Data were then exported to Microsoft excel for graphical representation and analysis.

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CHAPTER 4: RESULTS

4.1 Mopane trees distribution

The Mopane trees distribution was not even across the villages in Ward 12 as some of the trees were clustered whereas others were more scattered. The scattered ones were found around the homesteads of the villagers, whereas the clustered ones were found in open wooded areas with less human interference. The map in the figure 4.1 below illustrates the distribution of the Mopane tree as a resource base for mopane worms in ward 12 Beitbridge district with green representing vegetation and red bare soil.

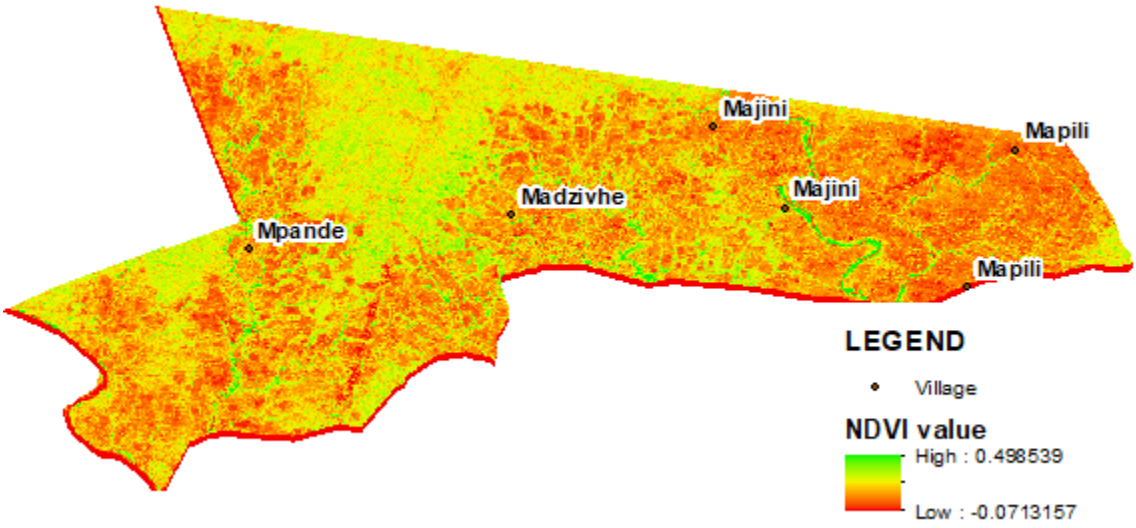

Figure 3 Map showing spatial distribution of Mopane trees in ward 12

4.2 Demographics of the respondents

There were thirty five respondents that were interviewed from the four villages that were sampled in ward 12. As per the data, 40% of people were women and 60% of people were men. The responders' average age was 49 years old. The sampled villages were Siyoka, Majini, Mpande and Madzive. Most of the respondents were from Siyoka due to its proximity to the main road as it was the most accessible of the villages. Majini and Madzive then followed it whilst Mpande was further away. Every respondent who took part in the interview was active in the Mopane worm trade and harvesting..

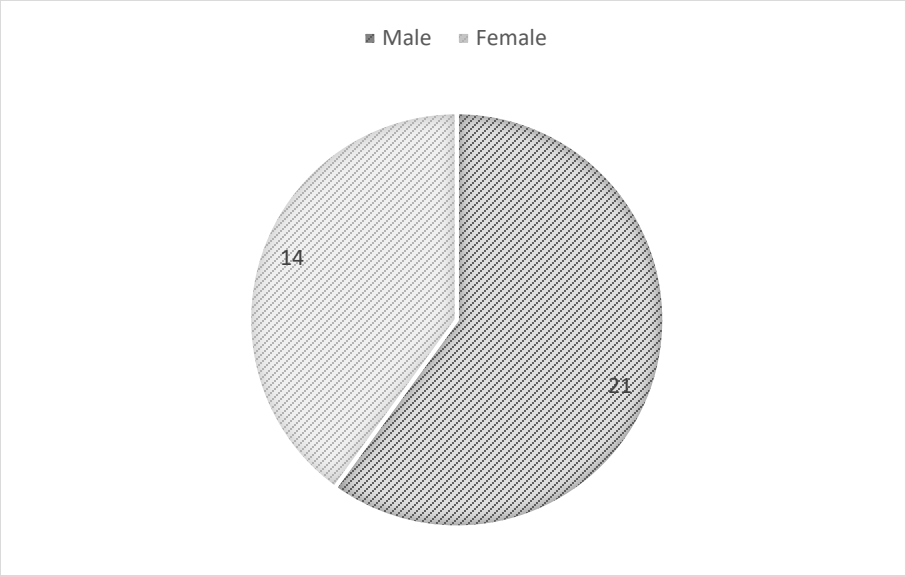

Figure 4 Respondents demographics

4.3 Processes and Quantities involved in Mopane worms harvesting

The mopane worms in ward 12 are harvested twice a year, the first outbreak season being in December and the second one in April. Collection of the mopane worms involved all the various groupings of the community that is Men, Women and Children. 70% of the respondents noted that the collection of the mopane worms is done by All (men, women and children) whilst 20% of the respondents pointed out that the worms were collected by women while 10% cited that they were collected by men.

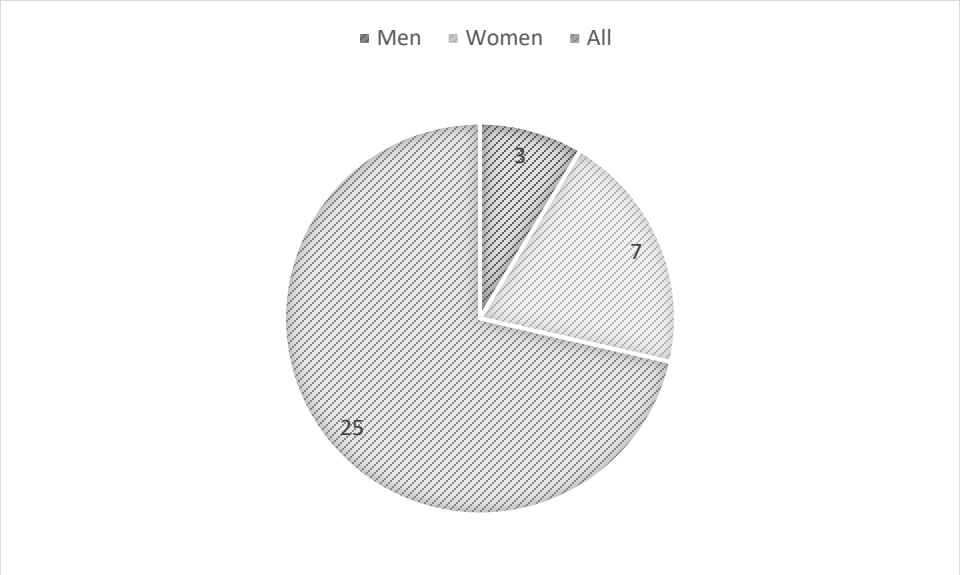

Figure 5 Mopane worm gender disaggregation

In terms of the harvesting and the techniques that were used in ward 12 it was noted that Plucking and Picking were the most common techniques that were cited by the respondents and no one owed the mopane trees as they were held in communal land tenure and the village heads supervised the utilisation of the worms. 80% of the respondents cited that they used the Plucking and Picking method. The plucking method involved taking down the mopane worms from the tree branches and then picking involved taking the worms from the ground as they drop off from the trees they will be foraging during their various life cycle stages. After harvesting the worms are then boiled in big pots so as to soften them as well as for the harvesters to remove the dirt from them before they are dried and conserved using salt.

On the quantities that are harvested per outbreak or season on average the respondents got eleven twenty litre buckets which would translate to approximately 220kg of the Mopane worms per season. This harvest is then spread over the outbreak months as most of the worms are harvested at the start of the outbreak and the yield gradually decreases as the season goes by. It is however important to note that during the El Nino induced drought the respondents cited that lesser quantities were harvested due to the prevailing extreme temperatures which burnt the Mopane worm's eggs before most of them could hatch to become full-fledged Mopane worms. The quantities that were harvested during the recent El Nino induced drought were as low as 2 twenty

litre buckets on average per household which translated to 40kg in the first outbreak to little or no worms in the second outbreak in April of this year.

The respondents also acknowledged that there were threats to the survival of the mopane worms and their resource base in the ward. Majority of the respondents pointed out to climate change as the major threat to Mopane worms harvesting with the advent of longer dry spells with high temperatures and little to no rainfall which are conditions that are not conducive to mopane worm's production. The other threats that the respondents pointed out were deforestation, overharvesting and veld fires and its illustrated by the figure below.

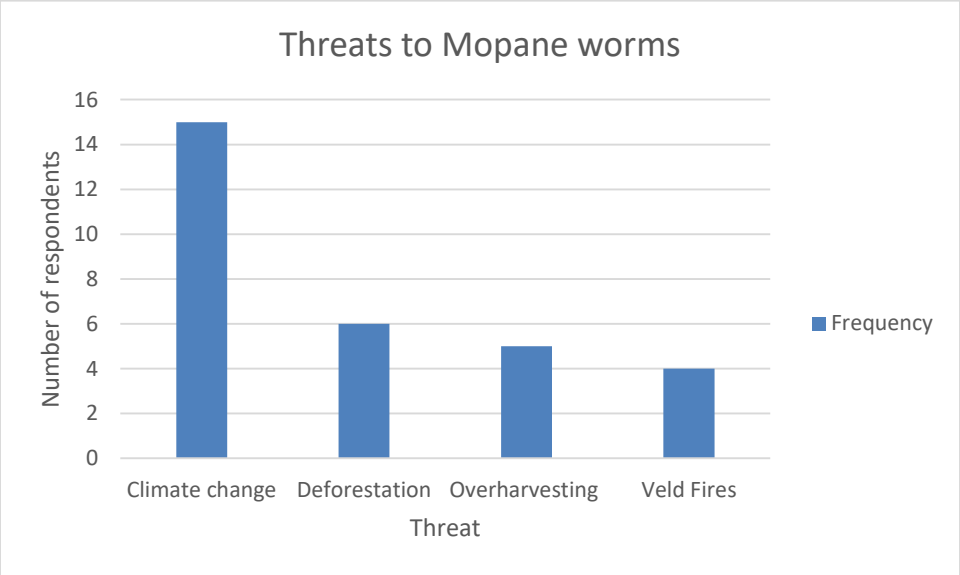

Figure 6 Threats to Mopane worms

4.4 The benefits of Mopane worms to ward 12 Beitbridge

The Mopane worms are held in high regard in the ward as they provide the much needed income for the community and also supplement their dietary needs. Majority of the respondents (60%) cited that they utilized the worms for both trading and consumption whilst 37% of the respondents used the worms for trading and 2% for consumption only. This is illustrated by the figure below

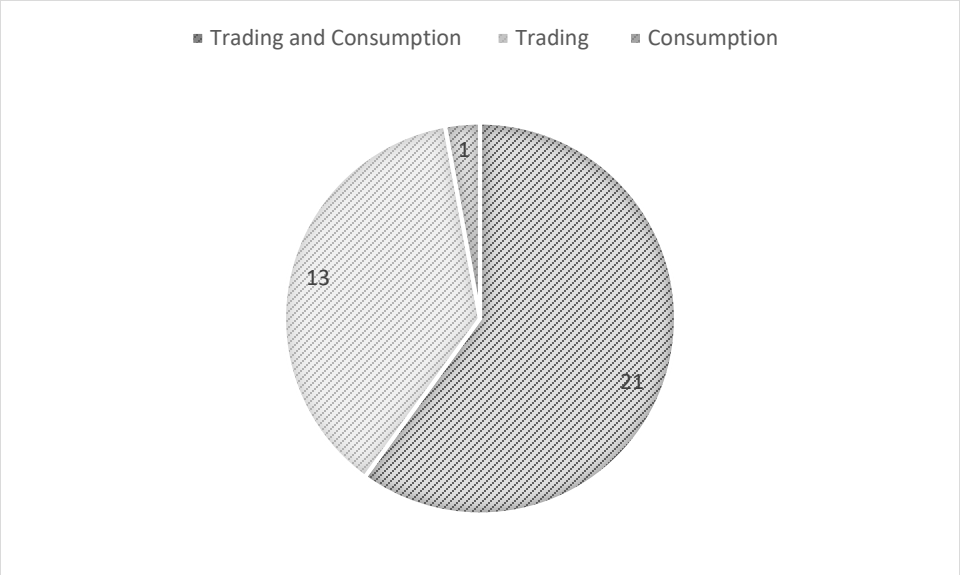

Figure 7 various benefits of Mopane worms

On the trade of Mopane worms from ward 12, the respondents got on average 6000 (ZAR) Rands from the sales of the worms per season. The income per sale would increase depending on the time of the sale as the worms appreciate in terms of prices months after the outbreak and when they are in short supply like in times of the El Nino induced droughts when they can go up to 700 ZAR per twenty-litre bucket. The mopane worm acted as the key source of revenue for the bulk of the respondents as 62% of them pointed out that it was their source of livelihood. The other 38% of the respondents cited that Mopane worm trade and harvesting was a secondary revenue source that was important in supplementing the income that they got from other livelihood options. The traders of the Mopane worms sell their produce to customer from neighbouring towns of Beitbridge, Gwanda, Bulawayo and some as far as Masvingo and Harare. As a dietary supplement, the Mopane worms are also utilized in ward 12 as they have a very high protein content. The average consumption per household, per outbreak season was 2 twenty litre buckets which can translate to around 40kg of the mopane worms being consumed per household.

CHAPTER 5: DISCUSSION

5.1 Mopane tree spatial distribution

The Mopane trees in ward 12 Beitbridge occur in the Savanah woodlands of Zimbabwe within region 5 which receives less than 800mm of rainfall per season coupled with higher temperatures which resonates well with other studies that were carried out by Sekonya et al, 2016 and Makhado et al 2014 in Sub-Saharan Africa were the conditions that prevailed in the places where these trees were found were dry regions which received less rainfall. In ward 12 the mopane trees were clustered in open woodlands and scattered in areas close to homesteads and business zones like schools and shops thus the scattering might have been due to clearing of the said land as people continue to settle and expand in area. The mopane trees in ward 12 are mainly found in communal land tenure thus to say no specific person had title or owned the trees but the village heads and chiefs were the ones who controlled the exploitation of the mopane worms as a resource. This is supported by other studies that have been carried out in Zimbabwe where the mopane woodlands come under different types of land tenure and access arrangements which includes homesteads (Stack et al, 2003).

5.2 Demographics of respondents

The majority of respondents that were interviewed were adults and this might be most of the working class in the set up are adults and the children would be at school. Of the total respondents interviewed 60% were males and 40% females which signifies a rise in the number of males that are involved in the harvesting and trading of Mopane worms. It also points out to men being cited as providers for their families hence in most male headed families the male would be tasked with mopane trading and harvesting. The 40% of the women interviewed may point out to women headed families or to scenarios were both male and females are helping each other in the trade. This is in line with studies that were carried out in Botswana were 74% percent of people involved in the harvesting of mopane worms were adults between the ages of twenty one and sixty, 8% were over 61 years (Stack et al, 2003). The demographics also align with the studies that were carried in Zimbabwe were due to the harsh economic climate, recurrent droughts, widespread unemployment and rapid inflation and families inability to sustain themselves all age groups both male and females had been pushed into the harvesting of mopane worms (Stack et al, 2003). This has been seen by a rise in number of men and youth in addition to women in the harvesting,

processing and trade of the mopane worms (Stack et al, 2003) which aligns with the high number of males that are involved in the mopane harvesting and trade from the study.

5.3 Processes and Quantities that are harvested

The Mopane worms outbreak occur twice a year in Ward 12 Beitbridge district the first being in December and the second on in April which is in line with studies that have been carried out in Southern Africa where in South Africa the mopane worm outbreaks occur twice in season thus one from December to January and the other one from April to May (Makhado et al, 2014) and in Botswana the first one is in December heading into January whereas the second one happens between April and May (Hope et al., 2009; Madibela et al., 2009). Majority of the respondents (80%) cited that they used the plucking and picking technique to exploit the mopane worms, which involved plucking them from tree, which had a reachable height, and picking them from the ground. This collaborates with other studies that were carried out by various scholars, like Stack et al (2003) which also noted that plucking and picking were the most used methods in terms of mopane worms harvesting.

The average quantities that harvested in a good season in ward 12 Beitbridge range from seven to eleven 20l buckets per season which would translate to 140kg to 220kg per season whereas in a bad season the average number of 20litre buckets that they would harvest range from 1-3 buckets which translates to 20kg to 60kg. This then aligns with other studies that have been carried out both internally in Zimbabwe and other countries as in Botswana harvesters in a good season reportedly get between 2-4 twenty litre containers a day of processed worms per person thus ending up with up to seven 25kg bags (350kgs) of dried worms at the end of the outbreak (Taylor, 2003). In a poor harvest season a person can collect one bucket a day and end up with at the most three bags (75kgs) at the end of the harvesting period (Taylor, 2003). In Zimbabwe studies that have been carried out show that communities' average mopane worm production ranged from 36kg–217kgs per household per season (Stack et al, 2003) with highest averages coming from the communities which were adjacent to commercial farms for example in Gwerima Chivi district (Stack et al, 2003).

5.4 Benefits of the Mopane Worms

The Mopane worms have various benefits in Ward 12, as they are a key economic activity that provide a livelihood for most of people in the ward. The main benefits of the Mopane worms from the study were trade and consumption though some of the respondents acknowledged that they were other uses or benefits of the Mopane trees that they knew but had not practised in the area for example the use of the worms for stock feed. Majority of the respondents (60%) cited that they utilized the worms for both trading and consumption whilst 37% of the respondents used the worms for trading only and 2% for consumption only. This resonates well with other studies that have been carried out in the region where these mopane worms are mostly found studies carried out in Giyani area of South Africa showed that mopane worms were being collected for their dietary supplements needs (Makhado et al, 2014). Furthermore, nutritional value of mopane worm is of importance with reasonably greater quantities of protein, fat, and carbohydrate than those found in chicken and beef (Moreki et al, 2012). Trade has also been a major highlight of mopane use with the worms being traded on a commercial basis in Zimbabwe, Botswana and South Africa showing a good economic return and providing a valuable source of income for many rural people (Mpuchane et al, 2001) which also aligns with the findings from ward 12 as more than half of the respondents cited that they used the worms for trade. The trade of mopane worms then provided the much needed income from the residents of ward 12 and on average the income that was generated ranged from 400 ZAR (rands) per 20litre bucket in times of plenty to about 700 rands per 20litre bucket when they are in short supply like during the recent El Nino drought. Studies carried out in neighboring South Africa showed similar trends with the price of mopane worms ranging from 752 ZAR and 1002 ZAR for an 80 kg maize meal sack of mopane worms (Makhado et al, 2014). Further studies in Namibia also resonates with what was transpiring in ward 12 as the income which the traders got from the sale of the Mopane worms averaged 716 ZAR per 50kg maize meal sack (Thomas, 2013). Locally in Zimbabwe the studies carried out have shown that mopane worms provide income in rural markets such as Mwenezi, Rutenga and Bubi as they sold for about US$0.33, US$0.42 and US$0.56 per kg respectively (Makhado et al, 2014).

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

The study carried out in Ward 12 of Beitbridge district showed that the Mopane trees were clustered in the open woodlands and scattered in areas close to homestead. The average quantities that are harvested per outbreak in a good season go as high as 220kg and significantly decline during the El Nino induced droughts to 70kg per season. The main harvesting techniques that are employed by the villagers of ward 12 in harvesting their Mopane worms are the plucking and picking methods which involve plucking from the tress and picking off the ground when the worms are in their fifth stage of pupation. A couple of benefits of the mopane worms came out from the study, that is consumption and trade as the villagers use the worms supplement their diets and they trade or sell the worms to get the much needed income to sustain their lives. Thus from the study several threats to Mopane worms emerged with the biggest threat being Climate change which had caused the occurrence of the El Nino induced droughts recently which then had a negative effect on the quantity of the worms that were harvested and the income that was generated from the sales of these worms**.**

Recommendations

The pertinent stakeholders (Forest Commission, Rural District Council, and Non-Governmental Organizations) together with the Ward 12 villagers should engage in different mopane trees sapling and seedling recruitment activities to cater for the lack of trees in areas that are around homesteads. This would go a long way in addressing the climate change issues which is causing these El Nino induced droughts. These stakeholders must capacitate the villagers on value addition and preservation so that they benefit more from the mopane worms during time of the El Nino induced droughts.

The community leaders are encouraged to enforce ward bylaws that safeguard the mopane trees and ensure that the worms are harvested sustainably so that in times of drought the community would easily fall back on them

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