# ABUNDANCE, DISTRIBUTION PATTERNS, ETHNOBOTANY AND ECONOMIC VALUE OF *Ximenia afra* SONG. IN COMMUNITIES SURROUNDING DZALANYAMA FOREST RESERVE, MALAWI

**MSc (FORESTRY AND ENVIRONMENTAL MANAGEMENT) THESIS**

**KHUMBO MATEMBA**

**MZUZU UNIVERSITY**

**DECEMBER 2025**

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**KHUMBO MATEMBA**

**BSc (FORESTRY)**

**A THESIS SUBMITTED TO THE FACULTY OF ENVIRONMENTAL SCIENCES, DEPARTMENT OF FORESTRY AND ENVIRONMENTAL MANAGEMENT IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE (MSc) IN FORESTRY AND ENVIRONMENTAL MANAGEMENT**

**MZUZU UNIVERSITY**

**DECEMBER 2025**

# DECLARATION

I hereby declare that this thesis titled, "Ecology and ethnobotany of *Ximenia afra* Sond. In communities surrounding Dzalanyama Forest Reserve, Lilongwe, Central Malawi" has been written by me and is a record of my research work. All citations, references, and borrowed ideas have been duly acknowledged. It is being submitted in fulfilment of the requirements for the award of the degree of Master of Science Degree in Forestry and Environmental Management of Mzuzu University. None of the present work has been submitted previously for any degree or examination in any other University.

6th January 2026

Khumbo Matemba Date

# CERTIFICATE OF APPROVAL

I, the undersigned, certify that this thesis is a result of the author's work, and that to the best of my knowledge, it has not been submitted for any other academic qualification within Mzuzu University or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on 08th December 2025

**Major Supervisor** Date

Associate Professor Victor Kasulo

**Co Supervisor** Date

Mr Dalo Njera

# ABSTRACT

*Ximenia afra* is an underutilized but seemingly vulnerable plant species that has received little attention despite its potential in areas of traditional medicine, the exploration of new drugs, commercial value and food sustainability. Ethnobotanical knowledge related *Ximenia afra* is at risk of being lost due absence of systematic documentation. This study aimed to assess the abundance, distribution patterns, ethnobotany and economic value of *X. afra* in communities surrounding Dzalanyama Forest Reserve. The data on abundance and distribution was collected through forest inventory, where stratified random sampling was used to set 40 plots. Purposive sampling was used to select 14 villages and 171 participants including 22 Key informants. Quantitative ethnobotanical indices such as plant part value (PPV) and fidelity levels (FLs) were applied. The study used the Contingent Valuation Method to assess the economic value of *Ximenia afra*. The results revealed low relative abundance (3.6%) and a clumped distribution pattern of *Ximenia afra* in the reserve. In the study area *Ximenia afra* is mainly used as a food source and as medicine to treat about 26 human and livestock ailments, including sexually transmitted infections (STIs), impotence, infertility and wounds. Study also discovered some indigenous beliefs and rituals associated with the plant demonstrating cultural and spiritual significance of species. *X. afra* hold economic value that contributes to the household economy through its products. There need to domestication the species to reduces pressure on wild populations, ensuring their continued availability in the forest. There is also a need to intensify research on Traditional Ecological Knowledge in Malawi to prevent the complete loss of this knowledge and thus help conserve biodiversity associated with such knowledge. The government should support small-scale processing of wild plant products to create income opportunities for communities to support their livelihood.



**Key words**: Abundance, Economic value, Ethnobotany, Medicinal use, *Ximenia afra*

# DEDICATION

I dedicate this work to my father and mother.

# ACKNOWLEDGEMENTS

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I further wish to acknowledge my classmates, whose collaboration and academic discussions provided motivation and support during challenging stages of this research.

# ACRONYMS

| | |
|---|---|
| CVM: | Contingent Valuation Method |
| FL: | Fidelity level |
| MK: | Malawian Kwacha |
| PPV: | Plant part use |
| RA: | Relative abundance |
| STIs: | Sexually Transmitted Infections |
| TA: | Traditional Authority |
| TEK: | Traditional Ecological Knowledge |
| WTP: | Willingness To Pay |

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# CHAPTER ONE: INTRODUCTION

## 1.1 Background

Knowledge of the ecology of tree species is critical to their existence and sustainable use. Ecology has been defined as the study of the interactions that determine the distribution and abundance of species (Krebs 1972). Understanding the abundance and distribution of species valued by humans is essential for guiding sustainable harvesting, developing effective conservation strategies, and assessing extinction risk (Ehrlén and Morris, 2015). Establishing a sound ecological understanding of such species along side utilisation patterns by communities, supports the development of appropriate protection measures (Joa *et al*., 2018).

Ethnobotany is the scientific study of the dynamic relationships between people and plants (Cruz-Garcia, 2014). It integrates socio-cultural, economic contexts, and people's values, perceptions, and views (Balick and Cox, 2020). Ethnobotanical research is critical for addressing global concerns, such as food insecurity, climate change, biodiversity loss, human health and contributes to biodiversity conservation (Pei *et al*., 2020). Ethnobotanical studies also help to reveal complex interactions between plants and people (Saha *et al*., 2014). The discipline also supports also supports efforts in biodiversity preservation, climate change mitigation, food and nutrition security, and human health (Kumar, 2021). Moreover, ethnobotanical research has been key in discovering medicinal plants and identifying wild edible species that can support food security in rural communities (Asaye *et al*., 2023). Unfortunately, this knowledge is at risk due to globalization, the ageing of experienced individuals, their unwillingness to transmit or share traditional knowledge, and the declining interest among younger generations (Esan *et al*., 2024).

Figure 1: *Ximenia afra* tree and fruits

*Ximenia afra* Sond. is a member of the Ximeniaceae family, formerly classified under Olacaceae. It is a deciduous tree reaching up to 6 m in height with a cluttered, open crown. The bark is dark grey and rough, becoming pale green or brown on younger branches (Baloyi and Yvonne, 2015). The branchlets are spine-tipped. The sapwood is white, and heartwood is hard and reddish brown. The species has a non-aggressive root system. Its green-whitish flowers occur in clusters within the axils of spines (Van Wyk and Van Wyk, 1997). These are followed

by oval, deep-red, white-spotted fruits that are edible to humans, animals, and birds (Figure 1). The fruits produced are known for their sour taste and dry aftertaste and are best consumed when slightly overripe. (Orwa *et al*., 2009).

*X. afra* is native to several African countries including Angola, Botswana, Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Namibia, Rwanda, Somalia, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe (Maroyi, 2016). It occurs widely in woodlands and wooded grassland, often on rocky kopjes and termite mounds. Like most medicinal plants, the species is predominantly harvested from the wild (Raimondo *et al*., 2009).

*Ximenia afra* is traditionally regarded as a multipurpose species with commercial, medicinal, and cultural significance (Nyila, 2025). Studies have shown that it has been used to treat a wide range of human diseases, including wounds, sexually transmitted infections (STIs), infertility, stomachache, fever, eye problems, diarrhoea, bilharzia, menorrhagia, malaria, intestinal worms, impotence, and coughs (Van Wyk, 2011, Maroyi, 2016, Maluleke *et al*, 2024). The bark and fruits are also used as ethnoveterinary medicine to treat dermatophytosis, foot rot, saddle sores, and control ectoparasites (Ndhlovu and Masika, 2013). Furthermore, oil from *X. afra* seed is traditionally used as a moisturiser, soap, and shampoo for dry, fragile, and damaged hair (Maluleke *et al*, 2024).

Indigenous people possess valuable ethnobotanical knowledge on neglected and underutilized species that can support sustainable land use systems, promote livelihood diversification and enhance climate resilience. These communities play a vital role as custodians of traditional wisdom (Georgiadis, 2022). This knowledge is intricately tied to their daily lives and interactions with natural resources in their environment (Nicholas, 2022). National and global

institutions increasingly recognise the need to comprehensively evaluate this knowledge to improve healthcare in remote areas (Panyaphu *et al*, 2012).

Globally, about 80% of people in developing countries, use medicine from plants as the primary mode of treatment for their illnesses (Zaidi *et al*., 2022). In rural Malawi, more than 80% of the population relies on the forest resources for fuelwood, construction, food, and medicinal use (Makwinja and Kimengsi, 2025). Charcoal burning and unsustainable harvesting of medicinal plants occur at a large scale, and these pose significant risks to the survival of medicinal plants.

Documenting traditional knowledge is essential for conserving biodiversity and enabling future research on the safety and effectiveness of medicinal plants (Bunalema *et al*., 2014). Safeguarding traditional knowledge also contribute to the realisation of Malawi vision 2063 (Enabler 1), which emphasis the preservation of cultural values that encourage hard-work, self-belief and other positive ethical norms. The study on underutilized food crop including wild fruits like *X. afra* will contribute to sustainable development goals (SDG), particularly SDG 2 (Zero hunger), through enhanced food and nutritional security.

## 1.2 Problem statement

Indigenous communities possess a wealth of traditional knowledge on the diverse uses of plants and serve as custodians of ancestral wisdom (Panyaphu *et al.*, 2012). *X. afra* is an underutilized but seemingly vulnerable species that has received limited scientific attention despite its potential in traditional medicine, the exploration of new drugs, and food sustainability (Maluleke *et al*.,2024). There is limited documentation of traditional knowledge related to use of *X. afra* in local communities, as most ethnobotanical information is memorized and

transmitted orally across generations, and is susceptible to changes or loss (Chisamile *et al*, 2021; Maliwichi *et al*, 2011; Muhakr *et al.*, 2024). This results in a loss of traditional knowledge, which may have taken generations to accumulate. This erodes important information that may have taken generations to accumulate.

There is also limited empirical evidence on the abundance and distribution of *X. afra* in Malawi. Documenting traditional knowledge and ecological information on *X. afra* can help meet present and future community's nutritional and medical needs (McMullin *et al*., 2019).

Although many studies have examined the ethnobotany of *X. afra* in other regions, have been carried out (Van Wyk, 2011; Maroyi, 2016; Maluleke *et al.*, 2024), none have focused specifically on its ecology and ethnobotany in Lilongwe, Malawi. As the use of plants varies across cultural groups and regions (Mahwasane *et al*., 2013), area-specific studies are important to capture local abundance, cultural differences and unique traditional knowledge associated with the species.

## 1.3 Objectives

### 1.3.1 Main objective

The main objective of this research is to assess the abundance, distribution pattern, ethnobotany and economic value of *X. afra* in communities surrounding Dzalanyama Forest Reserve, Malawi

### 1.3.2 Specific objectives

The specific objectives of this study are;

- To assess the abundance and distribution pattern of *Ximenia afra* in the Dzalanyama Forest Reserve.
- To determine the traditional knowledge on the use of *Ximenia afra* among community members adjacent to Dzalanyama Forest Reserve.
- To estimate the economic value of *Ximenia afra* products.

1.4 Research questions

- What are the abundance and distribution patterns of *Ximenia afra* in the Dzalanyama Forest Reserve?
- What traditional knowledge exists on the use of *Ximenia afra* among community members?
- What is the economic value of *Ximenia afra* products?

1.5 Justification

The successful conservation of biodiversity requires collaboration between scientists and indigenous communities (Eduard, 2023). The recognition of the value of traditional knowledge in this study will contribute to the preservation of cultural heritage and inform local conservation efforts of the species, and promote sustainable harvesting practices.

Documented the traditional medicinal uses of *X. afra* will guide future scientific exploration aimed at discovering new plant-based drugs. Local knowledge of the food value of *X. afra* fruits will contribute to nutritional and food systems development, supporting SDG 2 (Zero Hunger).

The study will also reveal the socioeconomic and cultural significance local communities place on *X. afra*. This information is important to policymakers as it will highlight potentially

valuable resources that can be integrated into promoting biodiversity conservation, protected area management and sustainable use initiatives. This is in line with the National Forestry Policy (2016), which promotes research on indigenous knowledge for sustainable management of forest resources.

Furthermore, the study contributes to Malawi Vision 2063 through cultural heritage preservation under Enabler 1. It will promote the preservation of cultural values that encourage hard work, self-belief and other positive ethical, and social norms which support inclusive wealth creation and self-reliance.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. Theoretical background

Ethnobotany has progressively evolved from a discipline that mostly documented the diversity of plant use by local people to an analytical and theory-driven discipline. This indicates the change within the field towards understanding the primary mechanisms and cultural, ecological, and socioeconomic factors that influence human-plant interactions. Several hypotheses have been developed to describe patterns in plant selection and utilization. Some of the hypotheses are the plant use value hypothesis, the resource availability hypothesis, and the urbanisation and knowledge loss hypothesis.

### 2.1.1 Plant use hypothesis

The plant use value hypothesis, developed by Phillips and Gentry (1993), suggests that the cultural significance or frequency of use of a plant, whether for medicine, food, construction, technology, and trade in a particular community, is influenced by its botanical family, life form, local abundance and maximum size. This hypothesis was adapted from the ecological apparency hypothesis developed by Feeny (1978), which categorises plants into apparent and non-apparent groups. Apparent plants are those that are easily noticeable due to their larger size and long-standing species, which are more visible and likely to be frequently encountered and utilised by humans. In contrast, non-apparent plants are small herbaceous plants that grow during early successional stages and are less likely to be utilised due to their limited visibility and availability (Feeny, 1976).

Philip and Gentry (1993) further developed the use value (UV) index which measures the plants' importance to humans based on the number of reported uses the species that are most commonly found in woodlands tend to have a higher use value. This approach has provided a

framework for incorporating statistical analyses into ethnobotanical research. The UV index considers the frequency of a particular plant species mentioned and the number of uses attributed to it (Zenderland *et al*, 2019; Lucena *et al*, 2012).

Despite its usefulness, the UV concept has limitations. It does not differentiate between the current and potential use of a species. Some plants might be widely known, yet infrequently used due to socioeconomic shifts, or knowledge erosion and changing environmental conditions (de Lucena *et al*, 2012; Albuquerque, 2006; Ramos *et al*., 2008).

Lawrence *et al*. (2005) challenged the assumption that a plant's usefulness is only determined by its traits, but also by sociocultural and demographic variables of knowledge holders. Factors such as gender, ethnicity, age, and proximity influence plants people select and how they use them. This suggesting the need to integrate ecological and human factors when analyzing plant use selection.

### 2.1.2 Resource availability hypothesis

The resource availability hypothesis suggests that plant species are used because they are easily accessible and locally abundant (Gaoue *et al*, 2017). It seeks to clarify why individuals favour a particular species over others, suggesting that usage patterns are connected to the distribution and availability of species (Guèze *et al*, 2014). The resource availability was adapted from the ecological apparency hypothesis initially proposed by Feeny (1976), first implemented in plant-herbivore interactions.

The concept of availability is frequently described as the proximity of a community to the location where a plant species naturally grows. However, broader definitions integrate additional factors such as seasonality, abundance, accessibility to markets or gardens, plant

pricing (Albuquerque 2006). These factors jointly impact the likelihood of a plant being utilized in traditional knowledge systems.

Although ecologically relevant, the resource availability hypothesis does not fully capture the social cultural significance, traditional knowledge transmission, and economic factors of plant use. Therefore, while it provides a valuable ecological framework, it must be integrated with sociocultural perspectives for a more robust understanding of human-plant relations.

### 2.1.3 Urbanisation and knowledge-loss hypothesis

The urbanisation and knowledge-loss hypothesis explores how expansion of urban areas and modernisation affect traditional ecological knowledge. It predicts that as urbanisation and commercialisation of plant products increase, traditional ecological knowledge and local plant use-wisdom decreases (Gaoue *et al*, 2017).

Several studies have documented the negative effects of urban expansion on ethnobotanical knowledge systems. For instance, Sogbohossou *et al*. (2015) reported the negative impacts of urbanisation on the preservation of local ecological knowledge. Rapid economic development often forces rural communities to abandon their traditional practices in favour of modern livelihoods and services.

This study integrates these theoretical frameworks to enable a holistic understanding of ethnobotanical dynamics. The frameworks collectively highlight the need to examine ecological patterns, plant characteristics, cultural and socioeconomic influences. Together they form the study analytical approach to understanding plant-use patterns.

## 2.2 Conceptual framework for the study

The conceptual framework (Figure 2), guiding this study demonstrates the interactions between ecological aspects and traditional knowledge. Traditional knowledge plays a critical role in

utilisation, management, and conservation within communities and identifies which plants to use.

The loss of traditional knowledge results in unsustainable use of plant resources, which led to overexploitation, degradation and potential species extinction(Moyo *et al*., 2015). Modern technologies and increased access to synthetic alternatives mostly disregards traditional ethnobotanical practices, reducing the dependence on indigenous knowledge systems.

By contrast, the use of traditional ecological knowledge results in sustainable utilisation of plant species. Many indigenous cultures have developed practices that ensure that natural resources are utsed in ways that maintain or even enhance their abundance (Sinthumule, 2023). When indigenous communities derive benefits from plant resources, they tend to assign value on them, and develop appropriate strategies for protection. When the tree plants are conserved, they give a historical identity and cultural symbolism to the ethnic group (Dawson *et al*., 2021).

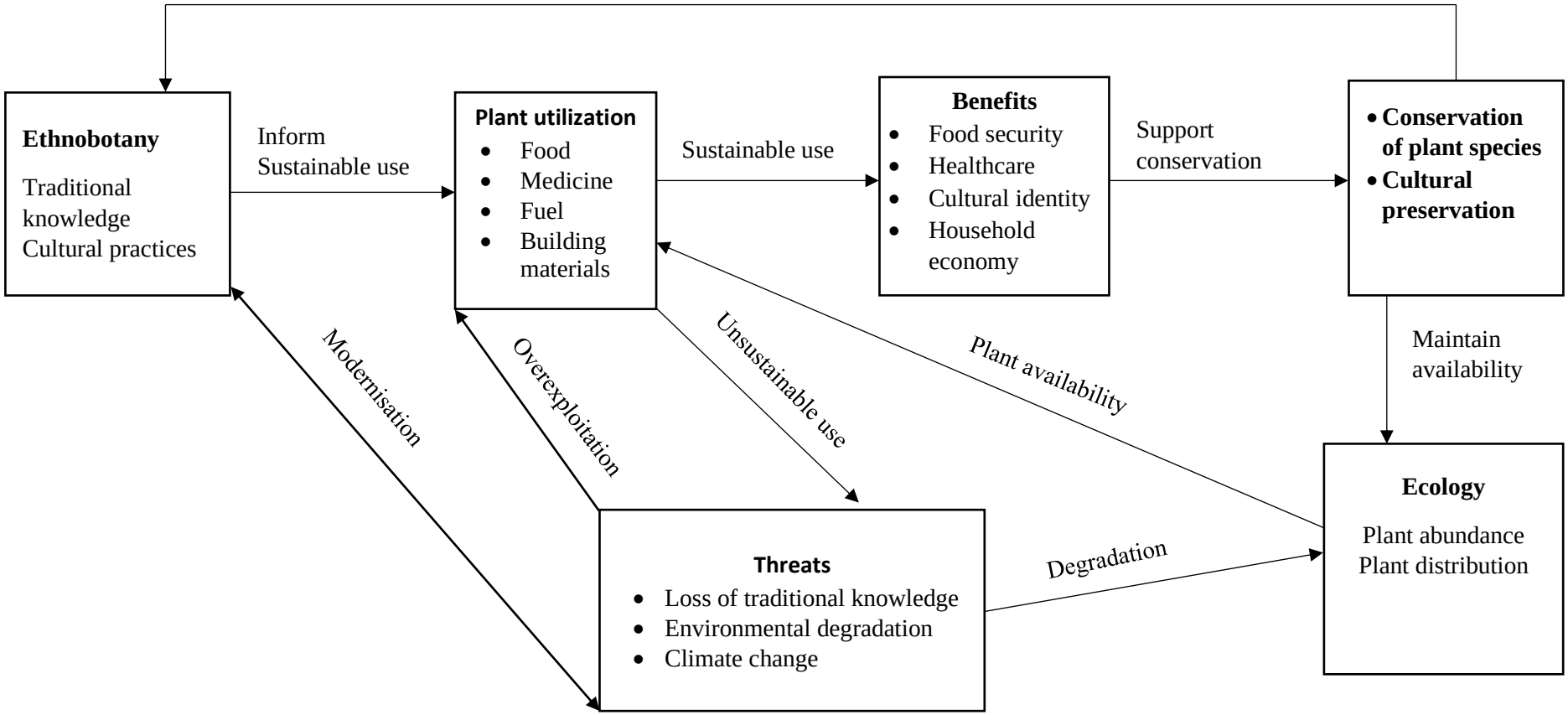


Figure 2: Conceptual framework of ecology and ethnobotany of *X. afra*

## 2.3 Empirical evidence

### 2.3.1 Medicinal uses of *Ximenia afra*

*Ximenia afra* is a multipurpose indigenous plant with diverse ethnobotanical applications across sub-Saharan Africa. Numerous studies have documented the medicinal importance of its bark, leaves, roots, seeds, and fruits, are used traditionally for medicine (Maroyi 2016, Maluleke et al. 2024). Maroyi (2016) showed that *X. afra* is used as traditional medicine in Angola, Botswana, Burundi, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Somalia, South Africa, Eswatini, Tanzania, Zambia and Zimbabwe, representing 83.3% of the species native range. Across these regions, the plant is used to treat about 65 human and animal ailments including wounds, sexually transmitted infections (STIs), infertility, stomachache, fever, eye problems, diarrhoea, bilharzia, menorrhagia, malaria, intestinal worms, and coughs (Maluleke *et al*., 2024; Maroyi, 2016).

Even though there is a broad regional documentation, there is limited information specifically for Malawi on the medicinal uses and abundance of *X. afra*. This gap justifies the present study, which focuses on Malawis' context. Phytochemical studies found that *X. afra* is rich in diverse bioactive compounds such as polyphenols, flavonoids, tannins, and terpenoids, which supports medicinal and nutritional properties (Maluleke *et al.* 2024). These compounds have anti-inflammatory, antimicrobial, and antioxidant properties, reinforcing the species value as a dependable source of medicine (Gakuya *et al*, 2013: Zhen *et al*, 2015: Shai *et al*, 2020). The leaves are used to treat skin infections, gastrointestinal disorders, and respiratory ailments (Maroyi 2016). The infusions of the roots are used to treat abdominal pain, bilharziasis, diarrhea, and dysentery (Maluleke *et al*., 2024). While Maroyi (2016) and Maluleke *et al*. (2024) highlighted on the medicinal uses of *Ximenia*

*afra*, they provide limited insight into the socioeconomic factors that influence community utilisation. This study addresses that gap by assessing the abundance and distribution patterns of *X. afra* and socioeconomic dynamics informing plant use.

### 2.3.2 Economic Potential for Value-Added Products of *Ximenia afra*

*Ximenia afra* plays an important economic role in several African countries. This fruit is used to produce alcohol products due to its unique flavour profile and nutritional composition (Maluleke *et al*., 2024). Its sour and tangy flavour makes it suitable for juice extraction and incoperation into refreshing drinks and functional beverages (Giampieri *et al.*, 2012; Maluleke *et al*., 2024).

Additionally, the seed of *X. afra* fruit is a source of oil (Orwa *et al*., 2009). In Botswana and Swaziland, the seed oil is traditionally used as a skin softener and a cosmetic ingredient, as well as for soap production (Long, 2005; Motlhanka *et al*., 2008). In Botswana, South Africa, and Swaziland, the oil is also used to soften leather, lubricate bows and bowstrings, lubricate farm machinery, and preserve dried meat (Maroyi, 2016; Long, 2005; Motlhanka *et al*., 2008). The fruits are sometimes processed into jams and jellies (Maroyi, 2016).

Although several studies have reported the economic potential of *X. afra*, the findings are based on ethnographic uses and qualitative descriptions. Quantitative economic valuation remains limited. Therefore, this study aimed to estimate the economic value of *X. afra* products in local communities adjacent to Dzalanyama Forest Reserve.

*Ximenia afra* is also commonly utilised for producing tool handles, wood carvings, and general construction material, as well as a source of firewood in various regions (Maroyi 2016). It also

holds cultural significance: For example, women from the Venda tribe in the Limpopo Province of South Africa wear a tassel made of *X. afra* bark during their initiation ceremonies. Similarly, the Ndebele people, also from the Limpopo and Mpumalanga provinces of South Africa, use the roots of *X. afra* mixed with cow dung to make a floor polish that protects against witches (Maroyi, 2016).

# CHAPTER 3: METHODOLOGY

This chapter contains an overview of the study area and explains the research design. It also presents the sampling methods and sample size, describes data collection processes for each objective and outlines the procedures used to analyse the data.

## 3.1 Study area

This study was conducted in Dzalanyama Forest Reserve and the surrounding communities. Reserve lies between latitudes 14.18° and 14.61° S and longitudes 33.35° and 33.92° E. It experiences a mean annual rainfall of about 800 to 1000 mm. (Munthali and Murayama, 2011). The terrain overlooks the Lilongwe plains, and rises between 1100 to 1659 m above sea level. The area exhibits a seasonal sub-tropical climate with average temperatures varying between 14.1 to 26.9 ℃.

The study focused on the section of the Reserve located in Lilongwe District within Traditional Authority (TA) Masumbankhunda, approximately 60 km 60 km from Lilongwe city. The area is predominantly a Chewa community who speak the Chichewa language. Despite the influence of Christianity and Islam, a good number of Chewa continue to uphold their ancestral traditional belief systems. The study area was selected because of the presence of *X. afra* within the forest reserve. It was assumed that local communities living around the reserve are likely to have a deep understanding of local plant species, including *X. afra*. Understanding how these communities use such species can help to determine ecological and cultural value, which in turn can inform

conservation efforts. uses for medicine, food, and other purposes. Local healers and elderly peoples, in particular, hold significant knowledge of medicinal plants and their healing practices.

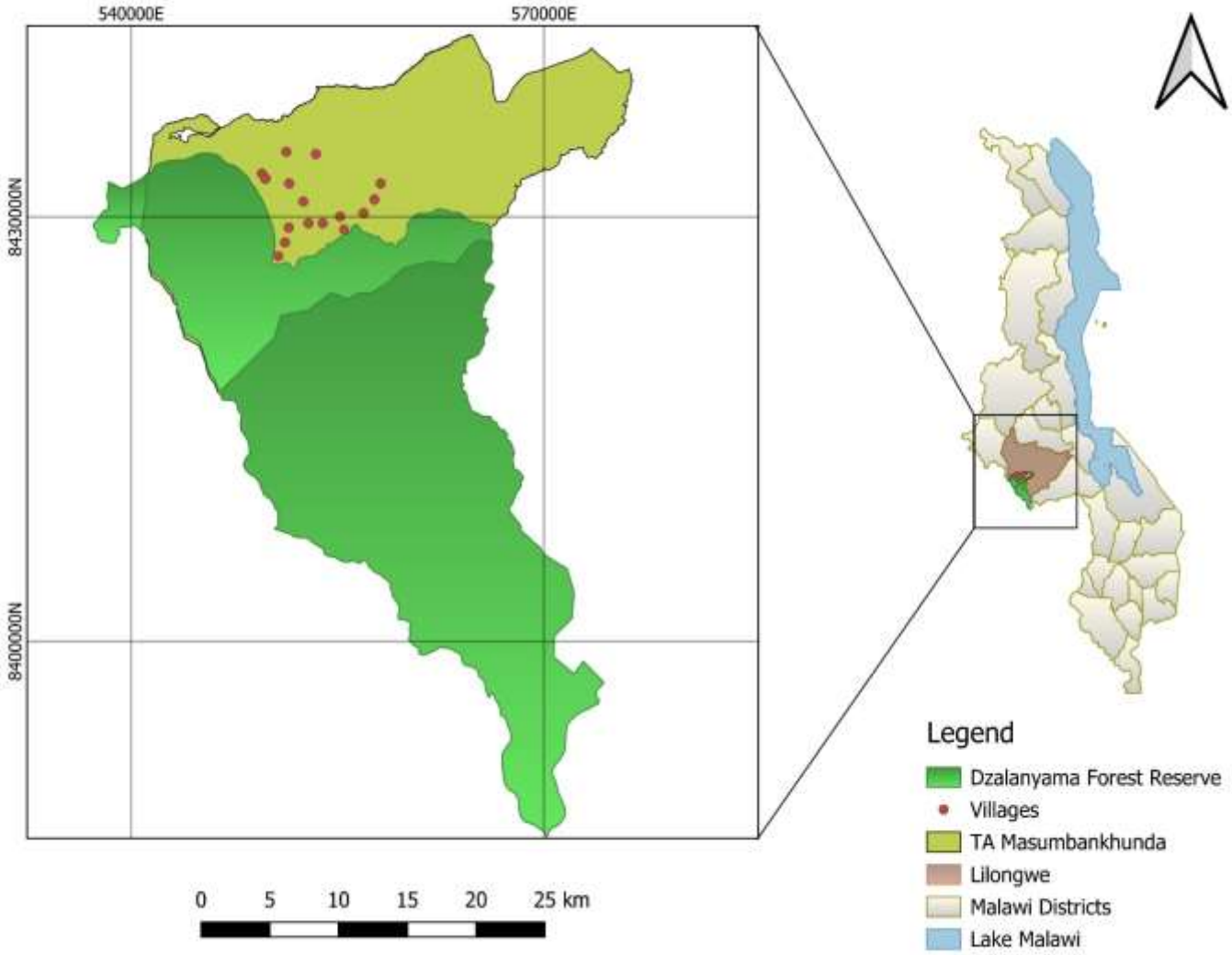


Figure 3: Map of Dzalanyama Forest Reserve

## 3.2 Research design

This study adopted a mixed-methods research design, integrating qualitative and quantitative approaches. Quantitative methods were used in forest inventory to collect data on the abundance and distribution patterns of *X. afra*. Additionally, quantitative ethnobotanical data such as frequency of use and percentage of respondents citing specific uses, were collected through the structured components of semi-structured questionnaires. Qualitative methods complemented this by capturing deeper insights through open-ended questions. within the questionnaires to obtain in-depth knowledge on the traditional uses, preparation methods, and cultural significance of *X. afra* from the local communities around the forest reserve.

The mixed method design enabled a comprehensive understanding of the ecological characteristics and ethnobotanical value of *X. afra*.

## 3.3 Sampling methods and sample size

### 3.3.1 Forest Inventory

Stratified random sampling was used to collect data on abundance and distribution patterns of *X. afra* in Dzalanyama Forest Reserve. The forest was divided into four strata, namely, high elevation, low elevation, high tree density area, and low tree density area. Stratified random sampling was used to ensure that all potential environmental and geographical variations are adequately represented, thereby improving the reliability and generalizability of the results (Tomppo *et al.*, 2014). Each stratum covered an area of 20 hectares, and was randomly sampled. Circular plots of 0.1ha with a radius of 17.8m radius were used. The plot size was selected because it is widely used in woodland ecological surveys to capture adequate representation of woody species. According

to Czaplewwski (2003), a minimum sampling intensity of 5% is recommended for forest management inventories. This study, therefore, used a sampling intensity of 5%.

The number of sample plots in each stratum was determined using the formula outlined by Malakini *et al*. (2020)

Number of sample plots = $\frac{ap}{s}$ **Equation 1**

Where *a* is the area of the stratum in ha,

*p* is the sampling intensity (5%),

*s* is the plot size in ha.

Using this formula, 10 plots were sampled in each stratum, making a total of 40 plots.

3.3.2 Ethnobotany survey

A purposive sampling was used to select villages and respondents in the communities adjacent to the Dzalanyama Forest Reserve. Purposive sampling, is an effective and a non-probability technique when the research involves knowledgeable respondents in a certain domain (Tongco, 2007; Soehartono and Newton, 2000). The sampling criteria included: villages located within 10 km from the forest reserve, respondents with direct knowledge and use of *X. afra*. A total of 22 key informants including, traditional healers, farmers and elderly individuals were purposively selected. Traditional healers provided knowledge on local medicinal practices and plant-based treatments. Elderly individuals shared valuable historical grounded insights. Farmers contributed practical knowledge of plant cultivation and use of wild plants. Snowball sampling was used to identify additional knowledgeable individuals where respondents recommended others with

expertise in *X. afra*. A total of 171 respondents were interviewed. The final number of respondents was determined by the saturation point, where additional interviews yielded no new information.

### 3.4 Data collection

In this study, quantitative and qualitative data were collected between December 2024 and January 2025. Primary data collection involved informant interviews and a forest inventory.

#### 3.4.1 Abundance and distribution pattern of *X. afra* in Dzalanyama forest reserve.

On each sampled plot, data was collected using data collection tool (Appendix 1): the number of *Ximenia afra* plants in the plot; the geographical position of each site including altitude, latitude and longitude; and, associated tree species in the plot. The indicators such as grazing, cutting for fuelwood roots and bark harvest were also observed to quantify human pressure. The handheld Geographic Information System (GPS) was used to record the geographical position of each plot. The forest inventory included experienced botanist and two research assistants. Botanist helped in the identification of associated species. The research assistants were recruited to support data collection in recording GPS coordinates, setting up the plot and species identification. To minimize errors and maintain consistency in data collection across all sampled plots, the research assistants were trained before the inventory.

#### 3.4.2 Traditional knowledge on uses of *Ximenia afra*

Individual interviews were conducted in a one-to-one conversational manner which was directed along the lines of topics specific to this study. A semi-structured questionnaire (Appendix 2) was developed and tested during the reconnaissance survey with a small subset of respondents to

confirm clarity and relevance of questions. Data on traditional knowledge on the uses of *X. afra* was collected from 14 villages adjacent to Dzalanyama Forest Reserve. The semi-structured questionnaire included the following question;

- What they use *X. afra* for?
- Which parts they use?
- Where did they hear about *X. afra?*
- if they use for medicine, what ailments do they use, how they prepare it, mode of administration?
- Have they shared information about *X. afra* with others?
- What is cultural significance of *X. afra*.?

Additionally, KI interviews were conducted, using a checklist (Appendix 3), with traditional healers, elderly individuals and farmers. Key informants are observant, reflective members of the community of interest who know much about the area of interest and are both able and willing to share their knowledge (Bernard, 2002). The two trained research assistants recorded all the responses on the hardcopy questionnaires.

### 3.4.3 Economic value of *Ximenia afra* products

This study employed the contingent valuation method (CVM) to estimate the economic value of *X. afra* products. CVM is commonly used to value goods and services that lack formal market prices. The respondents were asked:

- Whether they were willing to pay (WTP) for *X. afra*,

- How much they were willing to pay
- The reasons for their (un)willingness to pay, whether they buy or sell *X. afra* and at what price.

Primary data was collected using a semi-structured questionnaire (Appendix 2) from 171 respondents who were directly involved in the use of *X. afra*.

To ensure accuracy, WTP questions were targeted only to respondents who directly used a certain *X. afra* product. Follow-up questions were asked to assess the sincerity of stated WTP values. Additionally, socio-demographic data (age, sex, level of education, occupation, religion, and monthly income) were collected o identify factors influencing WTP.

## 3.5 Data analysis

### 3.5.1 Plant abundance and distribution patterns.

Relative abundance (RA) was used to estimate plant abundance. RA is the proportion of individuals of a particular species to the total number of individuals of all species in a given area or sample (Magurran, 2004). It provides an estimate of how common or rare a species is within a community and is expressed as a percentage. RA above 50% indicate that species are dominant, RA between 10% - 40% shows that moderately abundant, and RA value of 10% below indicates that species is rare in the sampled plots. Quantitative data from the forest inventory were summarised and analysed in Microsoft Excel. The relative abundance was calculated using the following formula.

Relative Abundance (RA) = $\frac{TS}{TP} \times 100$ **Equation 2**

where TS is the total number of species in the plot

TP is the total sum of the populations of all species in the plot

The non-parametric Kruskal-Wallis test (alternative to the ANOVA test) to determine any significant differences in species abundance in different strata. Kruskal Wallis test was used because the data was not normally distributed.

Index of dispersion was used to assess the distribution pattern of *X. afra*. Index of dispersion is a statistical measure used to describe the spatial distribution pattern of individuals in a population. determine whether individuals of a species are distributed randomly, uniformly, or clumped across the area (Krebs, 1998). Index of dispersion was calculated using the following formula:

$$\text{Index of dispersion (ID)} = \frac{s^2}{\bar{x}} \qquad \textbf{Equation 3}$$

Where: $s^2$ = variance

$\bar{x}$ = mean

when ID is greater than 1 means clumped distribution, when ID value is equal to 1 indicates random distribution and when ID is less than 1 it shows uniform distribution.

3.5.2 Use and benefits of *Ximenia afra*

Quantitative data from the questionnaire were cleaned, coded, and entered into the Statistical Package for Social Scientists (SPSS) version 20 for analysis. The descriptive statistics were carried out using percentages and frequencies. Quantitative ethnobotanical indices such as Plant Part Value (PPV) and Fidelity Level (FL) were also analysed.

Plant part value (PPV) is a value given for a specific plant part. It is equivalent to the ratio between the total reported uses for each plant part and the total number of reported uses for a given plant. It shows which plant part is culturally and medicinally most valued. High PPV (close to 1) shows most frequently used by informants and low PPV (close to 0) indicates less important or rarely used. It was calculated using the following formula (Gomez-Beloz, 2002):

Plant part value $PPV = \frac{RU_{Plant\ part}}{RU}$ **Equation 4**

Where: RU is the number of uses reported of all parts of the plant

$RU_{plant\ part}$ is the sum of uses reported per part of the plant.

Fidelity level (FL) is the percentage of informants who mentioned the use of a certain plant species for the same medicinal purpose in the study area. High FL indicates strong agreement on a plant's use, low FL suggests scattered or diverse uses. The FL index was be calculated using this formula (Ouedraogo *et al*, 2019)

$$FL = \frac{I_P}{I_U} \times 100$$ **Equation 5**

Where: $I_p$ is the number of informants who independently indicated the use of a species for the same major ailment

$I_{u:}$ The total number of informants who mentioned the plant for any major ailment.

Chi-square was employed to determine the association between the socio-demographic factors and the uses of *X. afra*.

### 3.5.3 Economic value of *Ximenia afra* products

The study used the contingent valuation method (CVM) to assess respondents' WTP for *X. afra* products, such as fruits, fuelwood and medicinal benefits. Respondents were asked if they would be willing to pay and the associated amount to collect *X. afra* products. To examine the factors influencing WTP, study used the Tobit regression model to determine the relationship between socioeconomic factors and WTP outcomes and Stata version 15 was used. Dependent and independent variables and their expected relationships were used in Tobit regression (Table 1).

Table 1: Description of Variables Used in the Tobit Model

| **Variable** | **Measure** | **Expected Relationship with WTP for fruits** | **Expected Relationship with WTP for medicinal use** | **Expected Relationship with WTP for fuelwood** |
|---|---|---|---|---|
| Age | Years | + | + | + |
| Gender | Sex (Male /female) | ± | ± | ± |
| Marital status | categorical | + | + | + |
| Education | Level of education | + | - | + |
| Occupation | Categorical | ± | ± | ± |
| Monthly income | Malawi kwacha | + | _ | + |
| Religion | Categorical | ± | + | ± |

The Tobit regression model was chosen to consider the censored nature of the dependent variable, where some respondents were not willing to pay where WTP value is zero. It is the most appropriate in analyzing dependent variables which have zeros, and dependent variables are

censored at zero. The model assumes that the decision to pay and the amount to be paid are made simultaneously, and that WTP values are observed only when they exceed a threshold (zero). The Tobit model as expressed by Halstead *et al*. (1991) was as follows:

$$WTP_i^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + \varepsilon_i$$

$$y_i = \begin{cases} y_i^*, & \text{if } y_i^* > 0 \\ 0, & \text{if } y_i^* \leq 0 \end{cases} \qquad \textbf{Equation 6}$$

Where by

$y_i^*$ = the latent (unobserved) willingness to pay.

$y_i$ = the observed WTP.

$X_i$ = a vector of independent variables.

$\beta$ = a vector of coefficients.

$\varepsilon_i$ = normally distributed error term.

### 3.6 Ethical consideration

Ethical approval for the study was obtained from the Mzuzu University Ethics Committee with reference number MZUNIREC/DOR/24/52 (Appendix 4). Respondents were thoroughly briefed on the rationale of the study and were asked for permission to participate (Appendix 5). Interviews were only conducted with the consent of the interviewee. Respondents were assured of confidentiality and anonymity as their official names were not to be publicized. The data were stored on password protected devices and questionnaires copies were kept in locked storage and

destroyed after data entry. Permission to conduct research within communities was sought from the Chiefs and access to the forest reserve was granted by Department of Forestry.

# CHAPTER 4: RESULTS

This chapter presents the findings of the study based on the data collected. It first outlines the abundance and distribution patterns of *X. afra* from data collected in Dzalanyama Forest Reserve. This is followed by analyses of traditional knowledge on uses of *X. afra*, including categories of plant uses, plant part value, fidelity level, knowledge transfer, and cultural uses. Lastly, the economic value of *X. afra*, including the results of the Tobit regression model to examine the influence of socioeconomic factors on respondents WTP.

## 4.1 The abundance and distribution patterns of *Ximenia afra* in Dzalanyama Forest Reserve

### 4.1.1 The abundance of *Ximenia afra* in Dzalanyama Forest Reserve

A total of 40 plots were randomly laid in distinct strata within the Dzalanyama Forest Reserve, with 10 plots in each stratum. A total of 36 *X. afra* trees were recorded in nine plots out of 40 sampled plots (Table 2), giving a frequency of 22.5 %.

Table 2: Number of *Ximenia afra* Trees Recorded across sampled plots

| **Strata** | **Plot ID** | **Number of *Ximenia afra* Trees** |
|---|---|---|
| Stratum 1 | S1P10 | 6 |
| | S1P5 | 3 |
| | S1P6 | 4 |
| Stratum 2 | S2P3 | 3 |
| | S2P4 | 4 |
| Stratum 3 | S3P10 | 5 |
| | S3P2 | 7 |
| | S3P4 | 2 |
| Stratum 4 | S4P2 | 2 |

The relative abundance of *X. afra* in the sampled plots was calculated to be 3.6%. Indicating that it is low-density species within the Dzalanyama Forest Reserve. The most dominant species were *Brachystegia species* (25%), followed by *Uapaca kirkiana*(22%), *Julbernardia species* (12%) and *Syzygium cordatum* (7%) as shown in Figure 4. Forestry staff members mentioned that the Reserve experiences fire every year. It was also observed that some areas in reserve are grazed by livestocks.

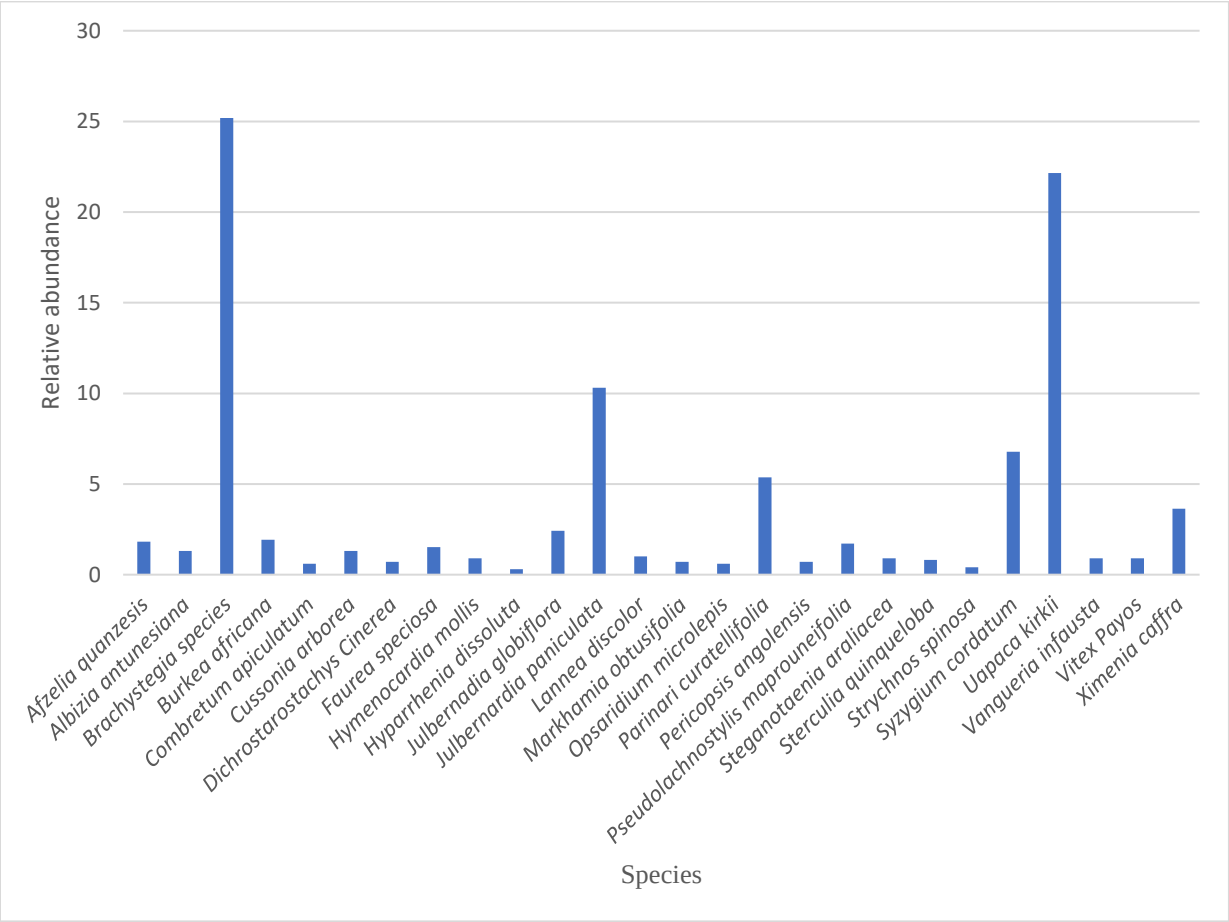


Figure 4: Relative abundance of trees in the sampled plots within Dzalanyama Forest Reserve

A Spearman's rank-order correlation test was also done between *X. afra* and all other associated species to assess any similarity in abundance. The results show that *Brachystegia utilis*, *Vangueria infausta*, and *Steganotaenia araliacea* have a strong positive correlation. (Table 3). In contrast, *Parinari curatellifolia* and *Uapaca kirkiana* show negative correlations *with X. afra*.

Table 3: Association of *Ximenia afra* with other woody species in the study area

| Species | Correlation Coefficient | P value |
|---|---|---|
| *Brachystegia utilis* | 0.793 | 0.001 |
| *Combretum apiculatum* | 0.353 | 0.025 |
| *Parinari curatellifolia* | -0.464 | 0.003 |
| *Steganotaenia araliacea* | 0.749 | 0.001 |
| *Uapaca kirkiana* | -0.411 | 0.008 |
| *Vangueria infausta* | 0.582 | 0.001 |

4.1.2 Distribution pattern of *Ximenia afra* in Dzalanyama Forest Reserve

Index of dispersion showed that *X. afra* has a clumped distribution pattern with an index of dispersion > 1 (I = 1.93), indicating that the species grows in clusters, which was statistically supported by a Chi-square test ($\chi^2 = 75.29$, degrees of freedom = 42, $p < 0.05$). It was observed that *X. afra* seeds fall directly beneath the mother tree. It was further observed that people and wild animals eat fruits onsite and leave the seeds under the tree, which might also lead to clusters, as shown in Figure 5.

Figure 5: *Ximenia afra* seeds and fruits beneath the tree

4.2 Traditional knowledge on the use of *Ximenia afra* among Dzalanyama communities

The study documented the traditional knowledge on uses of *X. afra* among communities around Dzalanyama Forest Reserve. The traditional knowledge on the following were assessed, categories of use of the species, the value of different plant parts, the associations between socio-economic variables and uses, the fidelity level for various ailments, plant parts used for treatment and their preparation methods, and the harvesting practices. It also examined local perceptions on population changes of the species, the transfer of traditional knowledge, and the cultural beliefs associated with it.

### 4.2.1 Use categories of *Ximenia afra* around Dzalanyama forest reserve

The study revealed four main categories of use for the *X. afra*: food, medicine, fuelwood and poles for construction (Figure 6). Food stands out as the most predominant use, accounting for 100% of cases mentioned from harvesting to edible fruits. Medicinal use was the second most common category with 52% respondents stating that *X. afra* is used to treat various ailments. The use of fuelwood was mentioned by 32% of the respondents, A small proportion 5% reported its use as constructing materials, mainly poles for roofing and fences, while 2% used the species to make handicrafts.

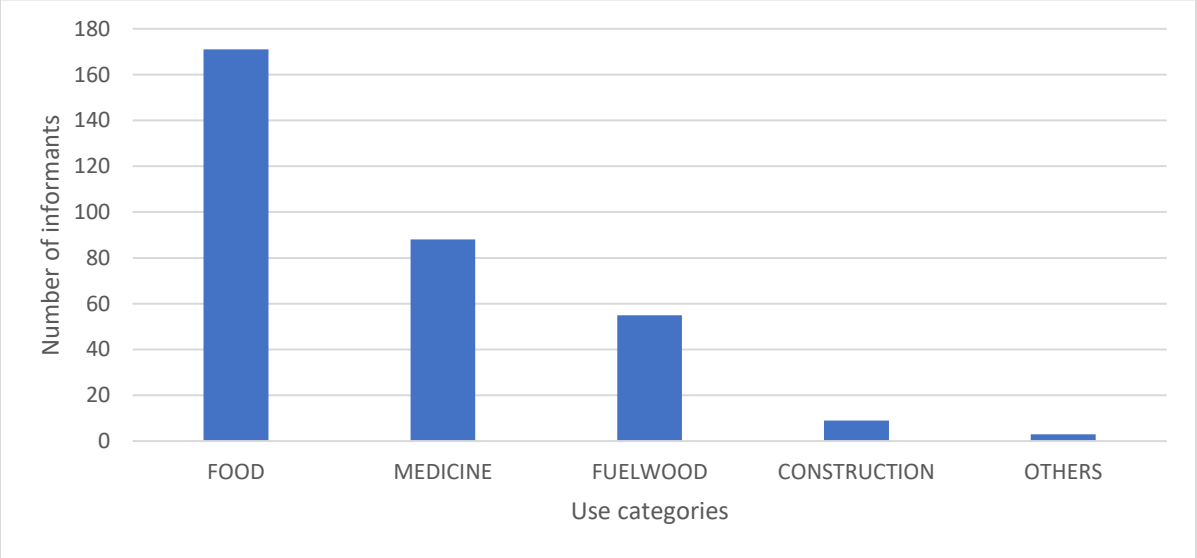


Figure 6: Use categories of *X. afra* by number of informants around Dzalanyama Forest Reserve.

### 4.2.2 Plant Parts Value

The Plant Part Value (PPV) analysis showed that fruits were the most predominantly utilized part of *X. afra*, followed by roots, stem, leaves, and bark (Figure 7). Fruits were most valued for food

and medicinal purposes, particularly for eye problems and stomach aches. The roots were widely used for treating wounds, ringworm, STIs, infertility, and impotence. Respondents explained that their choice of the plant parts was based on inherited tradition rather than an understanding of different compounds concentrations.

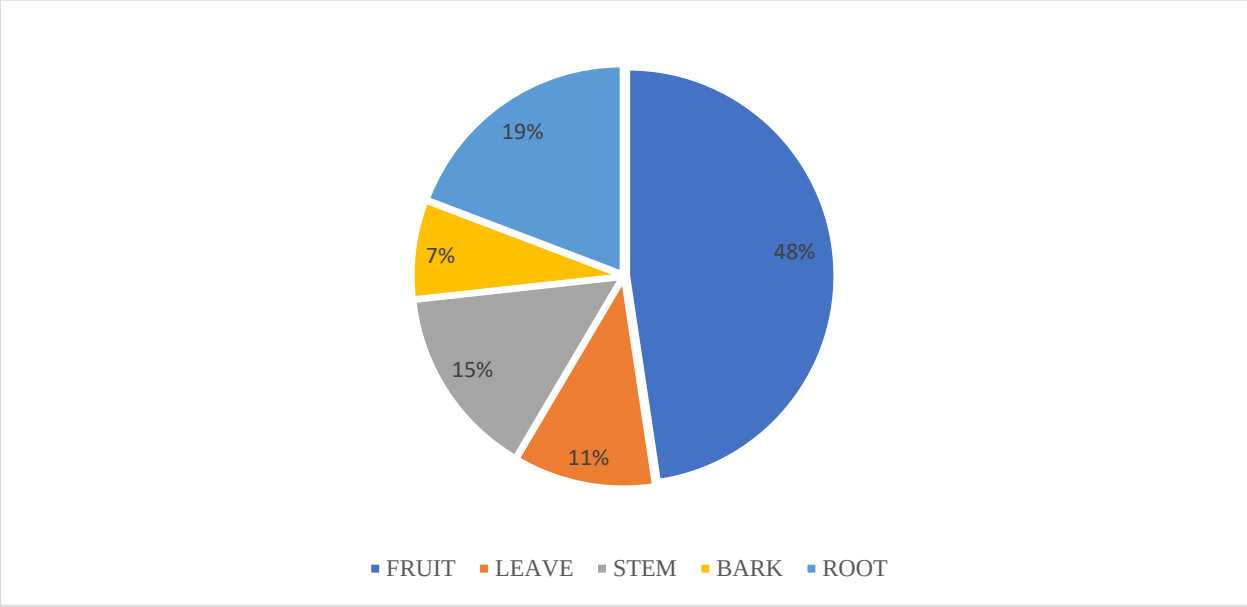


Figure 7: Plant part value for *Ximenia afra*

4.2.3 Association between socio-economic variables and use of *Ximenia afra*

Chi-square test was performed to assess the association between demographic variables and the use of *X. afra* (Table 4). The results indicated that age, gender, occupation, monthly income, and religion were significantly associated with medicinal use. Monthly income and occupation showed the strongest associations. Gender ($\Phi$ = -0.229) showed negative association indicating an inverse relationship. No significant associations were found use (which was constant across groups), fuelwood, building materials, or other uses.

Table 4: The associations between demographic variables and the medicinal use of *X. afra*

| **Demographic variable** | **Chi-Square ($\chi^2$)** | Phil (Φ) | **P value** |
|---|---|---|---|
| Age | 8.903 | 0.228 | 0.031 |
| Gender | 8.999 | -0.229 | 0.003 |
| Marital status | 1.278 | 0.086 | 0.734 |
| Level of education | 0.908 | 0.073 | 0.635 |
| Occupation | 17.12 | 0.316 | 0.002 |
| Monthly income | 22.55 | 0.363 | 0.000 |
| Religion | 17.88 | 0.309 | 0.000 |

4.2.4 Fidelity level

The fidelity level (FL) calculated the percentage of respondents who agreed on the use of *Ximenia afra* in treating different diseases. In this study, FL values ranged from 1.14% to 44.32% (Figure 8), with the highest value in treating sexually transmitted infections (i.e., Gonorrhea, Syphilis), followed by stomach-ache, and impotence.

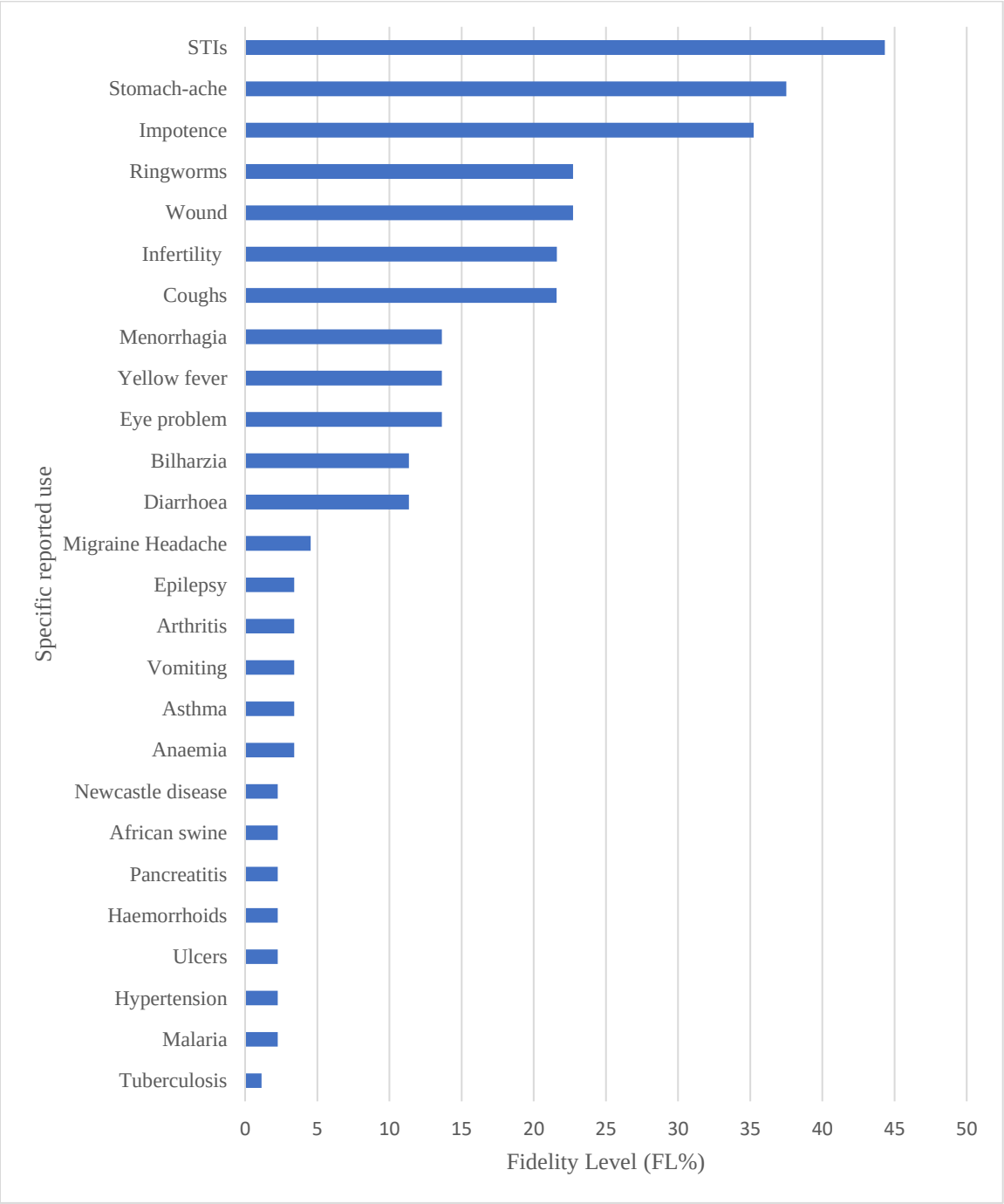


Figure 8: Fidelity level of the *Ximenia afra* for the various ailments

4.2.5 Plant parts used for the treatment of different ailments, preparation, and administration

A total of 28 different ailments, affecting humans and animals, were treated using different plant parts, including roots, leaves, bark and fruits. The common methods of preparation were soaking, burning, crushing, and decoction. The modes of administration included oral, topical, and eye drops, with oral as the predominant mode of application. Table 5 summarizes the detailed traditional medicinal applications of the *X. afra* recorded.

Table 5: Summary of traditional medicinal uses of *Ximenia afra*

| **Use** | **Plant part used** | **Preparation** | **Administration** |
|---|---|---|---|
| Eye problem | Fruit, leaves | Infusion/ Juice | Eye drop |
| STIs | Roots, leaves, bark | Burning/Decoction | Topical, oral |
| Infertility | Roots | Decoction | Oral |
| Ringworm | Root, leaves | Burning/crushing | Topical |
| Yellow fever | Roots | Infusion | Oral |
| Impotence | Roots, bark | Soaking | Oral |
| Menorrhagia | Roots | Decoction | Oral |
| Stomach ache | Leaves, roots, fruits | Infusion | Oral/chewing |
| Bilharzia | Roots | Decoction | Oral |
| Diarrhea | Leaves | Decoction | Oral |
| Epilepsy | Roots | Decoction/powder | Oral |
| Arthritis | Roots | Infusion | Oral |
| Cough | Roots, leaves | Infusion /powder | Oral, inhaling |
| Wound | Roots, bark | Burning/powder | Topical |
| Asthma | Roots | Decoction | Oral |
| Hypertension | Leaves | Infusion | Oral |
| Tuberculosis | Leaves | Infusion | Oral |
| Vomiting | Leaves | Infusion | Oral |
| Haemorrhoids | Roots | Decoction | Oral |
| Pancreatitis | Leaves, roots | Infusion | Oral |
| African swine | Roots | Crushing | Oral |
| Newcastle disease | Roots | Crushing/ Infusion | Oral |
| Ulcers | Leaves | Infusion | Oral |
| Malaria | Roots, leaves | Decoction | Oral |
| Migraine headache | Roots | Decoction | Oral |
| Anaemia | Root, leaves | Infusion | Oral |

4.2.6 Perceptions on population changes of *Ximenia afra*

Respondents perceived a decline in the availability of *X. afra* over time (Figure 9). Majority of respondents recalled that the species was highly abundant in the past. One of respondents stated, "*X. afra was commonly found in immediate surroundings, in our gardens, graveyards, it was very common, but now it is only present in the Dzalanyama forest reserve."* When asked about its present availability, majority of respondents perceived the species as moderately available, while smaller proportion still considered it highly abundant. In terms of future projections, most respondents projected that the species will become scarce.

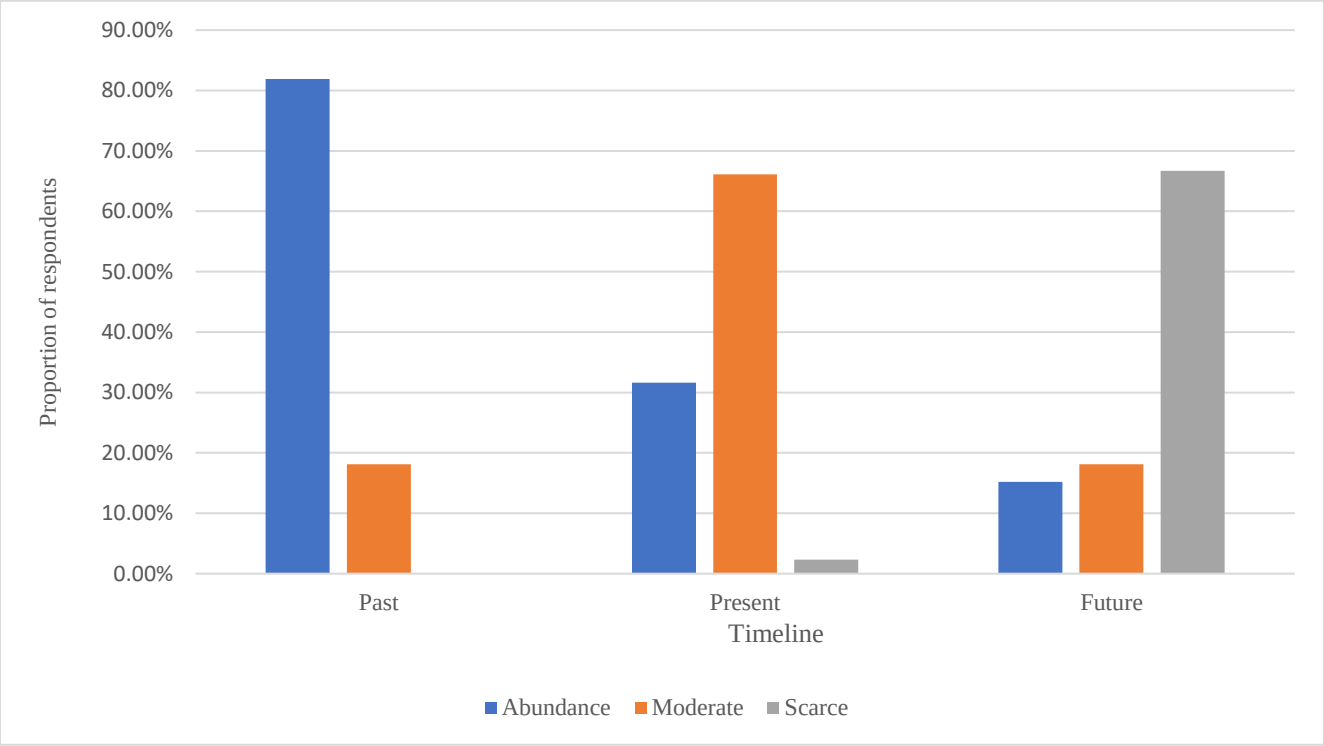


Figure 9: Perceptions of the informants on the abundance of *X. afra* over time

4.2.7 Traditional knowledge transfer among local people

Traditional knowledge associated with *X. afra*, was mainly acquired from parents, followed by friends, relatives, and to a lesser extent, herbalist (Figure 10). Respondents emphasized that traditional medicinal knowledge is often kept secret in this area. One of the respondents explained, "*information mainly for medicinal use is not simply shared with anyone because it affects the effectiveness of the medicine, we mostly keep it secret and share only when deemed necessary*". All respondents stated that traditional knowledge is preserved through memorising. Respondents stated that the information is passed from one generation to another through oral and observation.

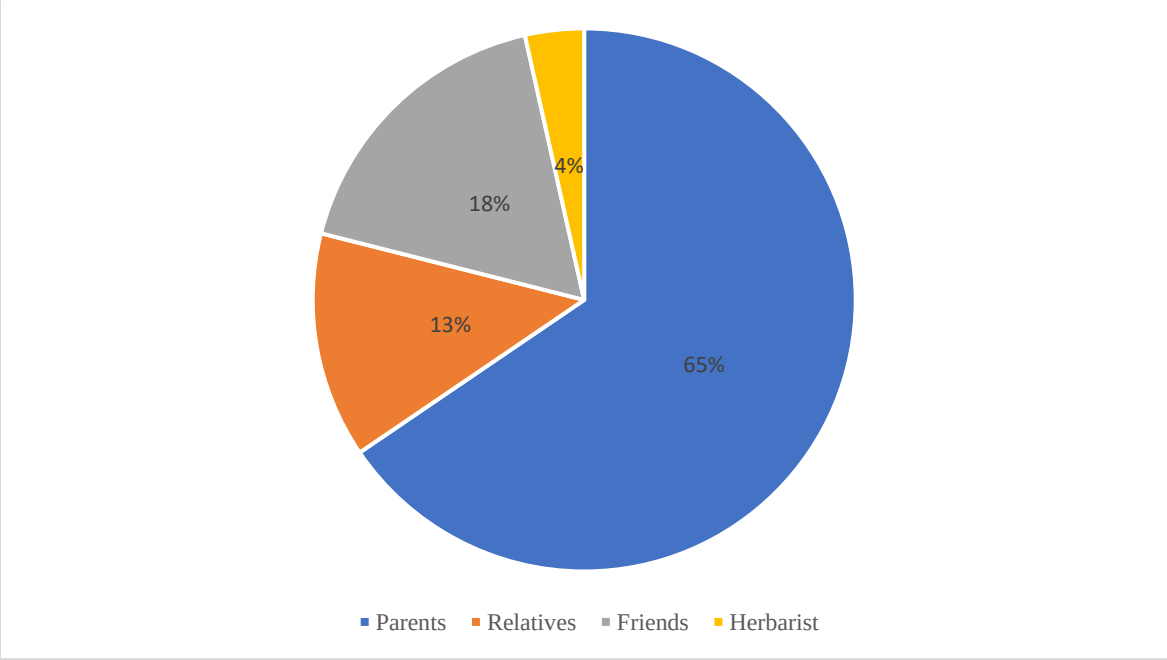


Figure 10: The informants' sources of knowledge about *X. afra*

### 4.2.8 Cultural briefs associated with *X. afra*

Several cultural beliefs and traditional practices were associated with *X. afra*. Respondents stated that they believe that when there is a sign of impending rain, if one consumes *X. afra* fruits while in the forest, one will get soaked by rain before reaching home. the species was also believed to possess spiritual power to protect their home from witches and to cleanse individuals who have been under the spell. Furthermore, some respondents reported that the roots are used in charms to protect their crops in the field from being stolen through magical means. Additionally, *X. afra* was associated with financial prosperity, with rituals performed for business success.

## 4.3 Economic value of *X. afra* products in communities around Dzalanyama

This section presents respondents' WTP across these three product categories including fruits, fuelwood and medicinal products to determine their relative importance and perceived value. The study also examined socio-economic variables such as income, education, occupation, religion, sex, age, and marital status if they influence households' WTP.

### 4.3.1 Respondents' willingness to pay for *Ximenia afra* products

The study found that 20% of respondents expressed unwillingness to pay for collecting the fruits in the reserve (Table 5). The reason for unwilling to pay being that that the natural forest belongs to them, with some mentioning financial constraints. Majority 80% expressed willing to pay for the fruits, mainly because they liked the taste of fruits and support sustainable management for future generations. The average amount they were prepared to pay was 416.96 MK, even though the amounts differed greatly.

Medicinal products showed the highest willingness to pay, with most users valuing them for their perceived healing effectiveness, affordability and to support sustainable management. Few were unwilling to pay mentioning financial constraints and that forest resources belong to them. The mean WTP for medicinal uses was MK 910.23, the highest compared to fruits and firewood products.

The study found that Fuelwood from *X. afra* was least value product. With respondents indicating unwillingness to pay mentioning poor firewood properties of *X. afra*, financial constraints, and that the forest belongs to the community. Some respondents (75%) were willing to pay between 200MK and 1000MK for a headload of about 10kg of firewood for household use, the average WTP amount of MK 347.27 as shown in Table 7.

Table 6: Respondents' willingness to pay for *Ximenia afra* products

| **WTP Amount** | **Fruits** | **Medicine** | **Fuelwood** |
|---|---|---|---|
| 0 | 36 | 6 | 14 |
| 200 | 1 | - | 2 |
| 300 | 12 | 2 | 7 |
| 400 | 21 | - | 5 |
| 500 | 63 | 32 | 24 |
| 600 | 20 | 2 | 1 |
| 700 | 2 | - | - |
| 800 | 9 | 1 | - |
| 1000 | 7 | 27 | 2 |
| 1500 | - | 4 | - |
| 2000 | - | 13 | - |
| 2500 | - | 1 | - |
| **WTP statistics (MK)** | | | |
| Minimum | 0 | 0 | 0 |
| Maximum | 1000 | 2500 | 1000 |
| Mean | 416.96 | 910.23 | 347.27 |
| Standard deviation | 259.42 | 595.78 | 224.84 |
| N | 171 | 88 | 56 |

1 US Dollar = 1751 Malawi kwacha

4.3.2 Factors influencing respondents' willingness to pay for *Ximenia afra* products

To identify the relevant factors to explain consumers' WTP for collecting *X. afra* products, a Tobit regression model was used. Results showed that only monthly income and education level have a statistically significant effect on respondents' WTP to collect *X. afra* for food (Table 6). Monthly income has a positive and significant coefficient ($\beta = 106.67$, $p = 0.001$). Similarly, education demonstrates a strong positive influence ($\beta = 177.77$, $p < 0.001$). There was no statistical significance regarding sex, age, occupation, marital status, or religion.

For medicinal purposes, results showed that several variables, including monthly income ($\beta = 326.06$, $p < 0.001$), occupation ($\beta = 114.91$, $p = 0.036$), Religion ($\beta = 253.68$, $p = 0.007$), and education ($\beta = -286.53$, $p = 0.021$), significantly influenced respondents' willingness to pay. Other variables, including sex, age, and marital status, were not statistically significant.

On fuelwood, Tobit regression results revealed that respondents' monthly income had a positive and statistically significant association ($\beta = 197.27$, $p = 0.001$) with their WTP for the collection of fuelwoods. In this study, households with higher incomes were willing to pay more than those that earn less. Other variables are not statistically significant predictors of WTP.

Table 7: Factors influencing WTP to collect *Ximenia afra* products

| | **Medicine** | | | **Fruits** | | | **fuelwood** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| | Coef. | Std. Err. | P>\|t\| |
| Sex | 5.467 | 128.48 | 0.966 | 6.607 | 48.983 | 0.893 | 26.891 | 79.731 | 0.737 |
| Age | -17.688 | 71.646 | 0.806 | -13.961 | 26.494 | 0.599 | -48.304 | 43.502 | 0.272 |
| Education | -286.531 | 121.417 | 0.021 | 177.769 | 43.679 | 0.001 | -18.362 | 82.718 | 0.825 |
| Marital status | -35.256 | 202.61 | 0.862 | -45.272 | 65.514 | 0.491 | -249.299 | 128.295 | 0.058 |
| Religion | 253.678 | 90.961 | 0.007 | 45.094 | 41.77 | 0.282 | 31.131 | 66.505 | 0.642 |
| Occupation | 114.913 | 53.87 | 0.036 | -22.577 | 21.36 | 0.292 | -13.422 | 38.775 | 0.731 |
| Monthly income | 326.055 | 79.486 | 0.001 | 106.666 | 31.855 | 0.001 | 197.269 | 56.335 | 0.001 |
| _cons | -17.753 | 521.525 | 0.973 | 76.804 | 173.015 | 0.658 | 427.5146 | 303.554 | 0.165 |
| var(e.wtp_~e) | 237143 | 37641.32 | | 76803.4 | 9939.737 | | 71507.25 | 16958.19 | |
| Number of obs | 88 | | | 171 | | | 55 | | |
| LR chi2(7) | 43.08 | | | 47.70 | | | 16.75 | | |
| Prob > chi2 | 0.0001 | | | 0.0001 | | | 0.019 | | |
| Pseudo R2 | 0.033 | | | 0.0236 | | | 0.027 | | |
| Log likelihood | -630.564 | | | -987.619 | | | -300.504 | | |

# CHAPTER 5: DISCUSSION

The chapter discusses the main findings of the study and relate them to existing literature, and reflect on their implications on conservation, livelihoods, and policy.

## 5.1 Abundance and distribution patterns of *Ximenia afra*

### 5.1.1 Abundance of *Ximenia afra* in Dzalanyama Forest Reserve

The study found that *Ximenia afra* has low abundance within the Dzalanyama Forest Reserve. The relative abundance of 3.6%, and occurrence in only 9 out of 40 plots (22.5% frequency) indicated that the species has a low abundance in the reserve. This suggests that its abundance and population size might be restricted by ecological and anthropogenic factors. According to niche theory, every species has range of environmental characteristics which it can have positive growth (Hutchinson, 1957). Factors such as soil condition, altitude and climate can limit species abundance, as they create conditions that are favorable to some species while also hindering other species (Thammanu *et al*., 2021).

Competition with other dominant species for the same resources, including water, nutrients, and light, could be another factor as stronger species can outcompete the weaker species (Lyu and Alexander, 2022). Results showed that the dominant species were *Brachystegia* spp. (25%), *Uapaca kirkiana* (22%), *Julbernardia* spp. (12%), and *Syzygium cordatum* (7%). Shirima (2015) reported that these dominant miombo tree species are known for their competitive dominance on resources over non-dominant tree species. A study by Munishi *et al* (2011) found that *X. afra* had a low indicator value in miombo woodlands, indicating it is not a dominant species in Miombo woodlands. According to Janick and Paull (2008), *X. afra* grows well in open space, suggesting that Miombo dominant species affect the *X. afra* abundance.

Anthropogenic pressure can also be a cause for the low abundance of *X. afra*. The enormous medicinal uses of *X. afra* by local community members as they prune the foliage, debark the stems and dig for tree roots can affect plant growth, leading to low abundance. This agrees with Mohammed *et al*. (2021), who reported that these reduce the quantity of foliage and interrupt tree growth. Intensive livestock grazing and browsing also affect the natural regeneration of trees and lower the species abundance in frequently grazed areas (Ball and Tzanopoulos, 2020). Forest fire experienced in the reserve could be another reason for the sparse abundance of *X. afra* as tree seedlings fail to survive due to fires. According to Orwa *et al.* (2009), *X. afra* has good seed germination capacity, but most seedlings fail to grow due to forest fires.

The study found significant association between *X. afra* and other associated species. The results revealed that *X. afra* had a strong positive relationship with *Brachystegia utilis, Vangueria infausta,* and *Steganotaenia araliacea* . These associations suggest that they share common habitat preferences. This is supported by Munishi *et al* (2011), as they stated that species respond uniquely to different environmental gradients, topography and edaphic factors, determining the plant species associations with other species as those that share common habitats grow together. Conversely, correlation analysis showed a negative relationship with *Parinari curatellifolia* and *Uapaca kirkiana,* suggesting that *X. afra* may not grow in areas where these species are dominant due to competition or ecological factors. Studies agree that tree associations sometimes affect the growth of individual trees negatively, mainly due to competition for limited resources (Aakala *et al*., 2013).

There is need for proper fire management, livestock grazing management, conservation and regeneration strategies to make sure that *X. afra* does not increasingly become rare in the reserve. There is also a need for further investigation into soil characteristics, disturbance patterns, and regeneration strategies that would be necessary to better understand the ecological

dynamics shaping the abundance and distribution patterns of *X. afra* in the Dzalanyama Forest Reserve. Also research on abundance and distribution of *X. afra* in the country ought to be conducted to determine its status at national level.

### 5.1.2 Distribution patterns of *Ximenia afra* in Dzalanyama Forest Reserve

The distribution pattern of *X. afra* in the Dzalanyama Forest Reserve was found to be clumped. This indicate that *X. afra* grows closer to each other than being randomly or evenly dispersed across the reserve. The direct field observations revealed that *X. afra* seeds frequently fall beneath the parent tree, leading to natural clustering of seedlings. Alcántara *et al*. (2019), stated that the dispersal patterns of seeds influence the subsequent dynamics and structure of forest communities. According to Bleher *et al.* (2002), when the seeds don't disperse far from the parent tree, leads to a clumped distribution pattern of offspring. It was also observed that both humans and wild animals consume *X. afra* fruits onsite**,** often leaving the seeds directly under the canopy of parent trees. Muñoz *et al*. (2017), reported that this behavior can enhance seed density near mature trees, further contributing to the clumping pattern. The study suggests limitations in seed dispersal and leaving seeds beneath parent trees by wild animals and humans as some of the factors influence *X. afra* distribution patterns. Stiles (2000) reported that many seeds perish before or after germination due to poor physical conditions of the site they fall, but those that land on good conditions survive. Phumphuang *et al*. (2024) have related abundance and distribution to a species' ability to use resources and be able to compete with other species. Johnson and Bronstein (2019) suggest that climatic factors such as temperature and precipitation are key drivers to control species distribution and abundance directly when they exceed what the species can physically tolerate and affect photosynthetic activity and biological processes. There is need to ensure that low abundant indigenous species like *X. afra* are prioritized in national biodiversity conservation strategies.

## 5.2 Traditional knowledge on the use of *Ximenia afra* among Dzalanyama communities

### 5.2.1 Uses of *Ximenia afra* among Dzalanyama communities

All respondents reported using *X. afra* fruits for food, highlighting its cultural acceptance and nutritional relevance. This aligns with other studies that reported *X. afra* is consumed as food in several countries in sub-Saharan Africa (Maroyi 2016, Nyila 2025). The *X. afra* fruit, which is underutilised, is rich in several biochemical components that enhance human health and nutrition (Maluleke *et al*., 2024). The flesh of the raw fruits is consumed by humans, the skin is discarded, and the juice is sucked. In some countries, including Angola, Botswana, Burundi, Ethiopia, Mozambique, Namibia, Rwanda, South Africa, and Swaziland, the fruits are also processed into drinks and jams (Maroyi, 2016). It was found that in the study area, no value-added processing is done on the fruit, indicating that the species is underutilised in the area whereby there missed opportunity to preserve the product and to process into new products. There need to introduce training communities on preserving and valued adding to wild fruits with simple technologies so that they can use it later when food is scarce and also sell other products at better price to enhance their livelihood.

Medicinal use was the second most commonly reported application of *X. afra*, with 51.5% of respondents mentioning it. Respondents stated various human and animal ailments that are traditionally treated using *X. afra*. According to Maroyi (2016), the bark, fruits, leaves, roots, and seeds of the sour plum are reported to have diverse medicinal properties and to treat a range of human and livestock ailments across its distributional range. The phytochemical study by Zhen *et al*. (2015) measuring the natural plant chemicals in *X. afra* found that it contains health-promoting antioxidant, antiproliferative, and anti-inflammatory activities. These this indicate that traditional knowledge provide correct information to treat different diseases. There is need to do more research on phytochemical analysis on different species wild species that are used

as traditional medicine as it can lead to explore new drugs. There also need to conserve these valued species by following sustainable harvesting practices to prevent overexploitation of these species. Also, there is need for more further research on traditional medicine to document the knowledge and which is at risk of being lost.

Fuelwood use was cited by 32.16% of respondents. The results suggest that *X. afra* is not the most preferred firewood in the study area Ruffo *et al*. (2002), reported that the species are a source of firewood in its distribution range.,. Most respondents stated that they use other species that have the best qualities they prefer for firewood. According to Sackser *et al* (2024), the choice of species is based on broad local knowledge of species, and this knowledge is associated with the available local flora, cultural believes and the essential properties of firewood like the heat they produce. For example, Venda people, South Africa never use *X. afra* for firewood because it was tabooed because of its medicinal value (Mabogo, 1990). Marquez-Reynoso *et al*. (2017) agreed that preferred species are associated with the duration of flame and embers, and the high calorific value they release during combustion. This shows that traditional knowledge and cultural believes can guide the use of plant resources. Therefore, there is needs to integrate traditional knowledge in national forest policies, forest management activities and conservation programs.

### 5.2.2 Plant part value

The findings showed that different parts of *X. afra* are utilized and valued in different ways by local communities in this study. Fruits were known to be the most used part of *X. afra*, with a 48% PPV. This is because the species is mainly used as food, as mentioned by all the respondents. Van Wyk (2011) also showed that the fruit of *X. afra* is rich in vitamin C, potassium, and protein. *X. afra* fruit pulp has a concentration of 49.2 mg of Vitamin C per 100 g, which is higher than some domesticated fruits (Ngemakwe *et al*. 2017). This shows that the

vitamin C found in *X. afra* contributes to the nutrition and health of rural communities that consume it (Nyila 2025). The species bear edible and fleshy fruits that have constituted part of the African diet since ancient times (Maroyi, 2016). In addition to food, it was reported that *X. afra* fruits are also used as a traditional medicine. Mapunda *et al*. (2019) reported that *X. afra* fruits have free radical scavenging ability and antiradical activities, indicating that extracts show excellent antiradical activities and free radical scavenging ability. The study discovered that roots were the second most used part of *X. afra* with a PPV of 19%. Roots are mainly used for medicinal purposes. Most ailments mentioned by respondents were reported to be treated by *X. afra* roots, including wounds, ringworm, sexually transmitted infections (STIs), infertility, and impotence. Respondents stated they believe that roots possess strong medicinal properties compared to other parts. This is similar to findings in Bie province, Angola, by Novotna *et al*. (2020), in traditional Zimbabwean medicine (Maroyi, 2011), and in the medicine of South Africa (York *et al*., 2011). A decoction prepared from the root was the most common way of preparing traditional remedies.

Stems and leaves were occasionally utilized, with PPVs of 15% and 11% respectively. According to respondents, stems are used for firewood and poles in the study area. The respondents admitted that species do not produce the most preferred poles, firewood and handicraft raw materials because of the size, shape and trunk straightness. Leaves are mainly used for medicinal purposes to treat several ailments, including eye problems, vomiting and stomach ache. Studies have also investigated the phytochemical composition of *X. afra* leaves, revealing the presence of bioactive compounds including flavonoids, phenolics, and tannins, which contribute to their healing potential (Zhen *et al*., 2015).

Bark is the least valued part of *X. afra* in the study area, with a PPV of 7%. The study findings show that bark is the least used by respondents, as it was only mentioned to treat three ailments,

STIs, impotence and wounds (Table 7). The informants were not aware that plant parts contain any active compounds. They stated that the choice is based on traditional practices and inherited knowledge from their ancestors. Several scientific studies have provided evidence that *X. afra* has medicinal properties (Zhen *et al*., 2015; Jacob *et al*., 2021). This suggests that traditional knowledge can be a valuable guide for identifying plant species with potential for medicinal development and there is need for further research on phytochemical analysis to identify elements found in plant parts.

The part of a plant species used determines the mode of harvesting. The harvesting of stems, bark and roots, however, poses a threat to the survival of the tree (Tugume *et al*, 2016) reported that harvesting of these parts, if not done properly, leads to plant mortality or exposes the tree to pests and diseases unless mechanisms for sustainable harvesting are put in place. This calls for proper harvesting guidelines and conservation measures for plant species sustainability.

5.2.3 Association between socio-demographic variables and use of *X. afra*

The results showed that socio-demographic variables influenced the use of *X. afra* in medicinal applications**.** The Chi-square test revealed that the socio-demographic variables, including Gender, Occupation, Age, Religion and monthly income, had a significant association with medicinal uses of *X. afra*. The study found that gender influences the medicinal use of *X. afra*. The negative Phil value indicated inverse relationship, demonstrating that men were more involved in the use of medicine than women. Chisamile *et al*. (2021) suggested that men dominance may be associated with the cultural and traditional practices of the people, which assign men with more complex duties and fieldwork such as farming, gravedigging, and hunting, helping them to learn more about traditional medicine. In contrast, Poli *et al*. 2025) found that women were more likely to seek treatment from traditional medicine practitioners than men. This may be due to traditional medicine being deep-rooted in cultural customs,

leading women to express strong faith in its effectiveness (Murugan and Yared, 2018). Traditional medicine is less expensive than modern medicine, which can, in some cases, influence women to prefer it. The study suggests that, because of culturally assigned duties, men spend more time in the forest hunting, charcoal burning and grazing animals, which exposes them to medicinal species, while women focus on household chores. The results indicate that gender roles influence how the knowledge is acquired and used. There is need to implement gender inclusive approaches for both male and females to make it accessible to both genders while conservation the wild plants.

Findings showed that age also influenced the use of medicinal applications. Older individuals were more involved in the species medicine applications and had more knowledge and experience compared to the youth. The older individual expressed trust in traditional medicine, while most young respondents indicated they prefer the modern health system. The study by Jima and Megersa (2018) in South East Ethiopia reported that young people were hardly involved in traditional medicine practice because they trust modern medicine. Showing that one of the factors contributing to low interest is the youth's exposure to modernization. The lack of interest of youths in traditional medicines hinders the number of people who can pass on the knowledge from one generation to another, and the death of herbalists leads to a loss of information (Tembo *et al*., 2021). The fewer youth interested use traditional medicine could result in loss of the traditional knowledge on medicine. There is need to incorporate ethnobotanic knowledge into education system that will validate the traditional knowledge which can make youth believe in the knowledge.

Religion has a significant association with the use of *X. afra* for medicinal purposes. The results showed that many respondents who belonged to traditional briefs were involved in the use of traditional medicine. While some who belong to Christianity stated that they don’t believe in

traditional medicine, citing that it is associated with witchcraft, which their beliefs do not allow. Wanzala and Walingo (2019) agree with this as they reported that with modernisation, development of conventional medicine and biotechnology, slowly, traditional medicine started being discredited with people, more particularly when missionaries and Christians in particular, called traditional medicine witchcraft, myth, evil, satanic, and ungodly. Conversely, Traditional briefs perform rituals, prayers, and ceremonies that involve healing practices to address spiritual causes of illness, which mainly involve the use of tree species to treat different physical illnesses. According to Mokgobi (2014), African Traditional Briefs, as a religion, ask God through the spirits of their ancestors to reveal to them secrets on how to treat the disease and which plant species to use. The refusal to use traditional medicine by some religious group risk the loss of traditional knowledge, hence, there is need to document the knowledge to conserve it from change religious briefs.

Occupation and monthly income showed strong associated with use of medicinal. The study found that herbalists and farmers were more involved in the use of traditional medicine. This suggests that individuals with informal occupations, such as herbalists and farmers, may be exposed to the use of natural remedies from their natural resources. It was also discovered that those who earn very little monthly income were more involved in the use of traditional medicine. This suggests that, because of financial constraints, they opt to use locally available natural resources since modern healthcare is expensive. The study by Logiel *et al*. (2021) on the use of traditional medicine and factors associated with this reported that People with a high level of income might have more capabilities to care for themselves and thus invest in health more than people with lower income. Some respondents mentioned that they use traditional medicine because they cannot afford to pay for modern medicine. The higher use of traditional medicine in many communities is due to poverty (Bhandari, 2021). This indicates that

traditional medicine is only affordable health care that local people can afford. This calls for conservation and sustainable harvesting of medicinal species so that local people can continue find access to traditional medicine.

### 5.2.4 Fidelity Level

The fidelity value helped to identify ailments for which *X. afra* is culturally and therapeutically important. FL values ranged from 1.14% to 44.32%, highlighting its multipurpose medicinal role in the study area (Table 6). High FLs for the treatment of sexually transmitted infections, such as gonorrhea and syphilis (44.32%), stomach-ache (37.5%), and impotence (35.23%), reflecting a strong belief in the plant's healing properties for these conditions (Friedman *et al*. 1986). Ailments such as tuberculosis (1.14%), hypertension (2.27%), ulcers (2.27%), and animal diseases like African swine fever (2.27%) and Newcastle disease (2.27%) had low FL values suggesting infrequent use (Hassan *et al*., 2017). This call for measures to conserve and sustainable harvesting practices for continued availability of the species. There is also a need for further phytochemical and pharmacological studies on high FL ailments as they can lead into discovery of new drugs. Also, there is need to document traditional knowledge on use of wild plants to avoid losing it.

### 5.2.5 Plant parts used for the treatment of different ailments, preparation and administration

The study showed that roots, fruits, leaves, and bark are used to treat 26 different ailments, with the roots being used in 73% of cases (Table 7). Leaves were also used to treat various ailments due to ease of access and harvesting. The respondents reported that they use roots following what elders taught them, that roots have strong healing properties compared to other parts. Some respondents mention that they use leaves because of easy access and harvesting. Achour *et al*. (2022) reported that the use of aerial parts, including stems and leaves or leaves

only, can be explained by the ease of harvesting and also the availability of these parts throughout the year. Malik *et al*. (2015) discovered that in some studies on medicinal plants in the Himalayan zone, roots and leaves were the most frequently used parts for different ailments.

A study found that respondents use different parts of *X. afra* in treating the same ailment. For example, both Roots, leaves, and bark were mentioned to treat Sexually Transmitted Infections and both Leaves, roots, and fruits are used to treat stomach aches. This aligns findings by Bhandari (2021) in Uttarakhand, India, who observed that medicinal plants can be used for more than one ailment, and one ailment can be treated by different parts of the same plant. Heavy reliance on roots could affect the health of the tree, this calls for educating traditional medicine users on proper harvesting practices to avoid injuring the tree and use of less sensitive parts such as leaves which does not bring harm on the tree.

Various methods of preparation are employed by local individuals, including decoction, infusion, burning, crushing, and soaking (Table 7). The predominant preparation methods are infusion followed by decoction. Infusion involves soaking plant parts in warm or cold water, and Decoction involves boiling plant parts in water. The study by Achour *et al*. (2022) aligns with this study, as they found that Decoction and infusion are the two most used preparation methods. It has been reported that preparations of *X. afra* are administered orally, topically, and as eye drops, with oral administration being the predominant mode of application. The study by Tembo *et al* (2021) on medicinal plants used for cervical cancer management in Zomba District, Malawi, also found that Oral administration was the preferred form of administration as it was considered easy to use and convenient. This is similar to most of the ethnobotanical studies (Chisaka, 2019; Bhandari, 2021; Chikowe *et al*., 2020). The findings showed that the selection of plant parts, preparation and application methods was inherited

from their ancestors following the results of centuries of trial, observation, and cultural validation. Respondents use these methods without a scientific understanding of phytochemistry, but these methods often agree with modern findings on the plant's bioactive properties. There is need to integrate scientific research with traditional knowledge set standardized dosages and ensure safety of patients when taking medicine.

### 5.2.6 Perceptions on Population Changes of *Ximenia afra*

The finding demonstrated that local communities around the forest reserve observe the changing trends in the abundance of *X. afra*. The study found that the majority of respondents (81.9 %) indicated that in the past, *X. afra* was highly abundant, as they stated that the species was found in immediate surroundings, in a graveyard and their garden. Respondents highlighted that currently *X. afra* is mainly found only in Dzalanyama Forest Reserve, suggesting the decline in its availability due to land use change. The change in land use, such as the conversion of natural habitats to agricultural is the main driver that leads to plant species decline as it reduces species habitats, making it hard for species to survive (Cabernard *et al*, 2024). On future projection, 66.7% of respondents predicted that *X. afra* will become scarce due to a high rate of deforestation and agriculture. In support of this, the study by dos Santos *et al*. (2021) reported that growth of human populations, land-use change, habitat destruction and over-exploitation of natural lands are main factors that lead to species scarcity or extinction. These perceptions are important because they are based on lived experience to support the formal ecological assessment. Gandiwa (2012) suggested that local people may serve as a valuable source of ecological information that could complement scientific information in community-based natural resources management programs. These findings emphasize the need for Community based conservation initiatives and development planning.

### 5.2.7 Traditional knowledge transfer among local people

The majority of respondents (65%) reported that they got the knowledge on the use of plants from their parents. Indicating that mainly indigenous knowledge is transmitted from parent to child. These findings are similar to the study by Chisamile *et al*. (2023) in Mzimba, Malawi, as it was found that most of the respondents (72%) mentioned that they acquired information on the use of plants from their parents. About 18% of respondents got the knowledge from friends and 11% from other relatives, indicating community networks in sharing the information. Only 4% cited herbalists as their source of knowledge, suggesting that herbalists are not a reliable source of indigenous knowledge due to secrecy, as they believe revealing certain remedies diminishes their effectiveness (Ozioma and Chinwe, 2019; Chikowe *et al*., 2020).

The study found that the method of transmitting traditional knowledge in the study area is mainly oral and observational. The knowledge is preserved by memorizing and passed on verbally. Respondent indicated that this knowledge is not documented or kept in written records. This puts the knowledge at risk of being lost or misinterpreted as the elder knowledge holders age and younger generations show less interest (Chisamile *et al*., 2023). According to Ali *et al* (2022), the transfer of knowledge from specialists to other members of the community is believed to be changed as new knowledge is added or skipped over the previous one in each step of transfer, suggesting that indigenous knowledge is not fixed but dynamic with this method. Therefore, there is need to preserve traditional knowledge on use of wild plants through documentation.

### 5.2.8 Cultural briefs associated with *Ximenia afra*

Beyond its nutritional and medicinal value, *X. afra* also holds cultural and spiritual importance. Beliefs that consuming the *X. afra* fruits when there are signs that it might rain, and will make the person before reaching home reflect cultural significance and may guide behavior. The community members also believe that the plant holds protective spiritual powers. Respondents stated that the tree has protective spiritual powers and is used to perform rituals to guard against witches, to protect crops from theft, cleanse individuals under a spell, attract financial prosperity. Such ritual uses are closely associated with broader patterns where wild plants play key roles in spiritual and ceremonial life (Ma *et al.* 2024). Recognizing these practices and beliefs can strengthen conservation efforts by aligning them with local values and belief system, which could enhance community participation in protecting the species.

## 5.3 Economic value of *Ximenia afra* products in communities around Dzalanyama

### 5.3.1 Respondents' Willingness to Pay for *X. afra* Products

All the respondents indicated consuming *X. afra* fruits, suggesting that it is culturally accepted and economically significant. Though these fruits are not found on local markets, about 80% of respondents expressed willingness to pay to collect the fruits with a mean WTP of 416.96 MK for a 500mg plate, indicating that majority in the area give *X. afra* economic value which showing that dietary importance and potential community support in conserving the natural resources. About 20% of respondents stated they are unwilling to pay, citing that forest resources should be free to access indicate the sense of ownership of forest resource, in which this sense of ownership can be used to involve them in conservation initiatives that they should be responsible on their resources. There is a need to encourage equal participation in

management and conservation activities to ensure continued availability of wild fruits that benefit them for food and cultural importance.

Medicinal resource had the highest WTP 910.23 MK, with 93% of medicinal users expressing willingness to pay. The mean WTP is higher compared to all other uses of *X. afra* in the community, indicating that community members were satisfied with medicinal purposes and valued it more in the local economy. This is similar to the study by Tran *et al.* (2016), who found that respondents were highly satisfied with traditional medicine and were willing to pay more. The high standard deviation of 595.78 indicates varied valuation of medicinal products in the community. The variations might be due to different income levels or personal trust in traditional medicine. In support of this, some informants mentioned that they are willing to pay more because they are satisfied with *X. afra* medicine. The high value medicinal use could lead to overharvesting, this calls for sustainable harvesting measure to make sure the wild plants are not endangered.

Fuelwood from *X. afra* is not commonly used in the study area. Only 56 out of 171 respondents indicated that they utilize the species for fuelwood, indicating is not main source of firewood in the area. Out of 56 Respondents, 75% expressed willingness to pay to collect fuelwood in the reserve, with a price range of 200 MK to 1000 MK per headload of 10 kgs on average. The mean WTP and SD were 347.27 MK and 224.84, respectively, indicating low valuation compared to other products, with respondents mentioning poor fuelwood qualities. The fuelwood qualities, such as flammability, flame brightness, flaming period, odour, smoke released, and ease of ignition, have an association with the preferences of the local population (Miah and Islam, 2020). In support of this, the informants indicated that they prefer other species than *X.. afra* for firewood indicating that it is secondary source of energy suggesting low harvesting pressure. There is need that conservation and management activities should

prioritize high valued economic and cultural uses such as medicinal and food, to encourage people to be part of initiative.

5.3.2 Factors influencing respondents' willingness to pay for *Ximenia afra* products

The Tobit regression model was used to assess the factors influencing respondents' willingness to pay for *X. afra* products used for food, medicinal, and firewood purposes. The results indicated that monthly income and education had a significant effect on WTP for fruits as food. The coefficient for monthly income was positive significant ($\beta = 106.67$, $p = 0.001$), the results showed respondents with low-income levels were willing to pay less amount to collect *X. afra* fruits and vice versa. This aligns with Omotayo *et al*. (2021), who found that households with higher monthly income and those who value indigenous plants are more inclined to invest financially in collecting them. The education ($\beta = 177.77$, $p < 0.001$) demonstrated positive influence on WTP as findings imply that individuals with no formal education attributed smaller economic value to *X. afra* fruits and vice versa. Nyongesa *et al* (2016) indicated that individuals with higher education levels tend to have a better understanding of the nutritional benefits of wild fruits and are more likely to make informed decisions when valuing ecosystem services compared to those without formal education. And Individuals with no formal education undervalue the wild fruits and this leads to little participation in management and conservation activities. There is a need to educate local communities with low education about the benefits of wild plants to their livelihood and encourage them to take part in conservation and management initiatives.

The findings revealed that monthly income, occupation, religion and education had a significant influence on respondents' willingness to pay for *X. afra* products for medicinal purposes. Monthly income had strong positive statistical significance ($\beta = 326.06$, $p < 0.001$), which indicate that individuals with higher income levels were willing to pay more for

traditional medicinal resources because they trust them vice versa. This aligns with Thorsen and Pouliot (2016) who challenged the assumption that the use of traditional medicine is for poor and marginalized people by showing that high income is an important determinant of the use of traditional medicine because they trust and value it. The study on determinants of traditional medicine use in northern Tanzania found that the use of traditional medicine is not limited to lower-income households but is also high in higher-income households (Stanifer *et al*., 2015). Occupation also had a significant determinant ($\beta = 114.91$, $p = 0.036$). Results showed that herbalists and farmers were willing to pay more for medicinal products than other occupations. This suggests high dependence on medicinal plants for their livelihoods. This aligns with a study by Stanifer *et al*. (2015), who found that herbalists were willing to pay between N500 and N1500 annually, while most of the others were willing to pay between N201 and N500 annually. There is need awareness to herbalist and farmers on sustainable harvesting practices and also involve farmers and herbalist in conservation and forest management activities who are direct beneficiaries of wild plants.

Religion had a significant positive influence ($\beta = 253.68$, $p = 0.007$): adherents of traditional belief systems were more willing to pay for *X. afra* medicinal products than Christians who associated traditional medicine with witchcraft (Logiel *et al*., 2021; Kiringe, 2005). There is need for more scientific studies that can validate the traditional medicine which some religions as it with witchcraft.

Education had a significant negative effect on WTP ($\beta = -286.53$, $p = 0.021$) on medicinal products. Similar results have been reported in the use of traditional medicine practitioner services for childhood illnesses in 32 sub-Saharan African countries (James *et al*., 2023) and preference and willingness to pay for traditional medicine services in Vietnam (Tran *et al*, 2015). Individuals with a higher level of education may be less likely to invest in traditional

medicinal products due to increased access to modern healthcare, greater awareness of biomedical treatments. There is need to for awareness and include traditional medicine in education system so the it may not be ignored with rise of education level and this can help also help in preserving traditional knowledge.

Monthly household income ($\beta = 197.27$, $p = 0.001$) was the only statistically significant predictor of factors influencing respondents' willingness to pay for *X. afra* for fuelwood. This indicates that individuals with lower monthly earnings were willing to pay small amount of money yet they rely much on forest for energy source. Individuals with higher monthly earnings were more likely to pay greater amounts for *X. afra* fuelwood, as fuelwood is the main source of energy in rural areas with no alternative sources like electricity. Kanagawa and Nakata (2007) investigated the link between energy, income, and health hazards in rural India and found that those with higher income value their time, so instead of going into the forest themselves to fetch fuelwood, they are willing to pay more to access fuelwood. Alem *et al*. (2016) suggests that households use multiple energy sources as they get richer, instead of completely shifting to modern energy sources as their income increases. There is a need to adopt alternative sources of energy to reduce pressure on forest trees. The government should subsidize other alternatives of energy such as biogas and improved cookstoves affordable and accessible to local communities.

# CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Conclusions

The study found that *X. afra* has low relative abundance and limited frequency in the reserve. The study suggest that low abundance is influenced by a combination of ecological, competitive, and anthropogenic factors. The positive and negative association of *X. afra* with other species indicate the interspecific interactions and shared environmental preferences with other species. The study also found that *X. afra* has a clumped distribution pattern in the Dzalanyama forest reserve. The clumped arrangement might be influenced by limited seed dispersal, as it was observed that most seeds fall beneath or near parent trees. Both humans and animals consume the fruits, and mostly the seeds are left under the tree, which could lead to clustering. While this study did not formally investigate the causes of *X. afra's* distribution patterns, existing literature suggests that factors such as dispersal mechanisms, competition, and environmental tolerances may contribute to the clumped pattern. This pattern might indicate a survival strategy under favorable ecological conditions.

A study found that *X. afra* is a valued plant in the livelihoods of communities surrounding the Dzalanyama Forest Reserve, as it is used as a food source, particularly the edible fruits. It is also used as medicine, as it was mentioned to be used to treat about 26 human and livestock ailments, including sexually transmitted infections (STIs), impotence, infertility and wounds. *X. afra* is also used for fuelwood, construction, and handicrafts, although its use is limited, as it was reported that *X. afra* does not possess the desired wood properties.

The study discovered a missed opportunity for processing and broader market use in the study area. Studies show that *X. afra* is used to produce value-added products, including oil from seeds, which is used to produce cosmetics and also used as a domestic biofuel. Others produce

drinks, jams and food additives from the fruit of *X. afra*. While in the study area, no value-added product was reported, this indicates that the species is underutilized in the area, even though it has economic potential that can improve their livelihood. This suggests lacks postharvest processing initiatives to extend fruit availability. Preserving fruit and selling it out of season can help communities to generate revenue to support their livelihoods and enhance food accessibility.

Local communities adjacent to Dzalanyama forest reserve have also demonstrated to have a wealth of knowledge about availability of species and changes that occur in species distribution and abundance around them including those arising from anthropogenic activities. This local ecological knowledge could be integrated with scientific knowledge and used in could significantly enhance efforts to identify, monitor, and conserve biodiversity.

The study demonstrates that *X. afra* is not only valued for its nutritional and medicinal uses but also for its cultural and spiritual significance. Indigenous beliefs and rituals associated with the plants reflect symbolic and spiritual roles of biodiversity. Iintegrating these cultural knowledge and beliefs with scientific approaches is essential for both cultural preservation and sustainable biodiversity conservation in which could enhance community participation in conserving the plant.

The study also revealed that *X. afra* holds economic value in communities around Dzalanyama, with fruits, medicinal products, and fuelwood, contributing to household economy, though these products does not contribute to cash household income rather than direct consumption. Socio demographic factors including education, religion, occupation and monthly income were found to be significant in influencing respondents WTP. Integrating its economic and cultural values into conservation can promote sustainable use and improve household livelihoods.

## 6.2 Recommendations

1. Domestication to reduces pressure on wild populations, ensuring their continued availability in the forest and supporting conservation efforts.
2. There is need to intensify research on Traditional ecological Knowledge and practices in Malawi to prevent complete loss of this knowledge and thus help conserve biodiversity associated with such knowledge.
3. Government should encourage small scale processing of *Ximenia afra* fruits and medicinal products and advocate for forest based micro enterprises to create income opportunities for communities to support their livelihood.
4. Documented cultural and spiritual values should be incorporated into local education and extension programs, ensuring intergenerational knowledge transfer.
5. The government should subsidize other alternatives of energy such as biogas and improved cookstoves affordable and accessible to local communities to reduce pressure of firewood on wild plants.
6. Community based conservation initiatives should incorporate traditional ecological knowledge to strengthen involvement of local people in monitoring, managing and protecting the wild species.
7. Awareness on proper harvesting practices to traditional medicine users to avoid injuring the plants when harvesting.
8. Government should encourage equal participation in management and conservation activities to ensure continued availability of wild fruits that benefit them for food and cultural importance
9. Further studies should be conducted soil analysis and microhabitat associated with *X. afra.*

10. Research on abundance and distribution of *Ximenia afra* in the country ought to be conducted to determine its status at national level.
11. There is need for further scientific research on traditional medicine to validate its use so that it can be accepted by all classes of people.

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## APPENDICES

Appendix 1: Data collection form

Plot number …… block number ……

Geographic coordinates ……Altitude …….

Number of *X. caffa* in plot…….

Associated species

| **No.** | **Local name** | **Scientific name** | **Number of plants** |
|---|---|---|---|
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Appendix 2**:** Respondents semi semi-structured questionnaire

**A. Social Demographic characteristics**

Name …….

Sex ☐ Male ☐ Female Age …….

Village ……. Traditional Authority ……

Level of education ……. Marital status……..

Denomination …… Tribe ……

Source of income ……

**B. Knowledge and use of *Ximenia afra***

1. Have you ever heard about *Ximenia afra*? ☐Yes ☐No

(If YES, please proceed; otherwise, that is the end of the interview)

2. When did you hear about *Ximenia afra*?.....

3. Where did you hear the information from?

☐ parents ☐ relatives ☐ friends ☐ other (specify)……..

4. Have you ever used *Ximenia afra*? ☐ Yes ☐ No

(If YES, proceed to 5 if NO, continue with 8)

5. What have you used *Ximenia afra* for?

☐ food ☐ medicine ☐ fuel ☐ building material

☐ other (specify)…….....

6. What parts of *Ximenia afra* have you used?

☐roots ☐ stem ☐ leaves a seed ☐ other (specify)

7. If you used it for medicine puroses, what ailments do you use? ……

……..

8. Describe in detail how do you prepare for each ailment
……

…….

9. How is the preparation administered?
……

……..

10. For how long have you used *Ximenia afra*?

☐ less than 1 year ☐ 1 - 5 years ☐ 6 -10 years ☐ 10 - 15 years ☐ more than 15 years

11. Have you ever heard of other uses of *Ximenia afra* apart from the uses you have mentioned above?

☐ Yes ☐ No

if NO, go to question 11

if YES.

12. what uses have you heard?

……..

**C. Economic value**

13. Are you willing to pay a certain amount of money to collect and protect *Ximenia afra*?

☐Yes ☐No

If No, go to question 13

If yes, how much would you pay?.....

14. What were the main factors you considered for your answer?
15. If you said no, which of the reasons below best explains your answer?

☐ Because the forest has no value to me

☐ Because my household income is too small to make any contribution

☐ Is difficult for me to specify a monetary value for the forest resources

☐ Because I feel that these resources belong to us

16. Do you sell or buy *Ximenia afra* products? ☐Yes ☐ No

if YES, to whom is it sold? …….

17. At how much is it sold …….

18. what is cultural significance of *Ximenia afra*?

Appendix 3: Key informants checklist

1. After you heard about *Ximenia afra*, have you seen the actual plant and where did you see it?
2. What are uses of *Ximenia afra*?
3. What parts did you use and what did you use them for?
4. Are there any beliefs that are associated with the use of *Ximenia afra*?
5. How much would you be willing to pay a certain amount of money to collect and protect *Ximenia afra*?
6. Why would you pay that mount?
7. Do you sell *Ximenia afra* products?, how much?
8. Do you conserve these plants?

Appendix 4: Ethical approval certificate

MZUZU UNIVERSITY

DIRECTORATE OF RESEARCH

Mzuzu University
Private Bag 201
Luwinga
Mzuzu 2
MALAWI
TEL: 01 320 722
FAX: 01 320 648

**MZUZU UNIVERSITY RESEARCH ETHICS COMMITTEE (MZUNIREC)**

**Ref No: MZUNIREC/DOR/24/52 25/10/2024.**

Khumbo Matemba,
Mzuzu University, P/Bag 201, Luwinga, Mzuzu 2.

Email: khumbomatemba@gmail.com

Dear Khumbo,

**RESEARCH ETHICS AND REGULATORY APPROVAL AND PERMIT FOR PROTOCOL REF NO. MZUNIREC/DOR/24/52: ECOLOGY AND ETHNOBOTANY OF XIMENIA CAFFRA SONG. IN COMMUNITIES SURROUNDING DZALANYAMA FOREST RESERVE, LILONGWE, CENTRAL MALAWI.**

Having satisfied all the relevant ethical and regulatory requirements, I am pleased to inform you that the above referred research protocol has officially been approved. You are now permitted to proceed with its implementation. Should there be any amendments to the approved protocol in the course of implementing it, you shall be required to seek approval of such amendments before implementation of the same.

This approval is valid for one year from the date of issuance of this approval. If the study goes beyond one year, an annual approval for continuation shall be required to be sought from the Mzuzu University Research Ethics Committee (MZUNIREC) in a format that is available at the Secretariat. Once the study is finalised, you are required to furnish the Committee with a final report of the study.

The Committee reserves the right to carry out compliance inspection of this approved protocol at any time as may be deemed by it. As such, you are expected to properly maintain all study documents including consent forms.

Wishing you a successful implementation of your study.

Yours Sincerely,

Wanangwa K. Msowoya
**MZUNIREC Secretariat**
**FOR: MZUNIREC CHAIRPERSON**


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Mzuzu University Research Ethics Committee
Directorate of Research
Mzuzu University
P/Bag 201
Luwinga
Mzuzu 2
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Cell: +265 (0) 99 5 48 32 93

Appendix 5: Informed consent form

**Mzuzu University Research Ethics Committee (MZUNIREC)**

**Informed Consent Form for Research in the Master of Science in Forestry and Environmental Management**

**Introduction**

I am Khumbo Matemba from Mzuzu university. We are doing research on the ecology and ethnobotany of *Ximenia afra* in communities surrounding the Dzalanyama forest reserve. This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them of me or of another researcher.

**Purpose of the research**

This research aims to understand and document how local communities around the Dzalanyama forest reserve use *Ximenia afra* and also understand the ecology of the plant.

**Type of Research Intervention**

This research will involve your participation in a group discussion and individual interviews.

**Participant Selection**

You are being invited to take part in this research because you know *Ximenia afra*.

**Voluntary Participation**

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. If you choose not to participate nothing will change. You may skip any question and move on to the next question.

**Duration**

The research takes place for a period of 10 months.

**Risks**

You do not have to answer any question or take part in the discussion/interview if you feel the question(s) are too personal or if talking about them makes you uncomfortable.)

**Reimbursements**

You will not be provided any incentive to take part in the research.

**Sharing the Results**

The knowledge that we get from this research will be shared with you and your community before it is made widely available to the public. Following, we will publish the results so other interested people may learn from the research.

**Who to Contact?**

If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact: Mr Khumbo Matemba at +256885409117/ +265997237343

This proposal has been reviewed and approved by Mzuzu University Research Ethics Committee (MZUNIREC) which is a committee whose task it is to make sure that research participants are protected from harm. If you wish to find about more about the Committee, contact Mr. Gift Mbwele, Mzuzu University Research Ethics Committee (MZUNIREC) Administrator, Mzuzu University, P/Bag 201, Luwinga, Mzuzu 2, Phone: 0999404008/0888641486

Do you have any questions?

**Part II: Certificate of Consent**

I have been invited to participate in research about ecology and ethnobotany of Ximenia *afra*.

**I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study**

**Print Name of Participant_____**
**Signature of Participant _____**
**Date _____**
**Day/month/year**

***If illiterate*** [1]

**I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.**

**Print name of witness_____** **Thumbprint of participant**

**Signature of witness _____**

**Date _____**

**Day/month/year**

**Statement by the researcher/person taking consent**

**I have accurately read out the information sheet to the potential participant, and to the best**

[1] A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who are illiterate should include their thumb print as well.

**of my ability made sure that the participant understands the research project. I confirm the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.**

**Signature of Researcher /person taking the consent_____**

**Date _____**

Day/month/year