Ethnoecological investigation of *Spirostachys africana* Sond. population at *Ha-Matsa* Village, Limpopo Province, South Africa

By

Mashudu Victor Phalanndwa

11531637

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Supervisor: Prof. MP Tshisikhawe

Co-Supervisor: Dr K. Magwede

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DECLARATION

I, Mashudu Victor Phalanndwa **[student number: 11531637],** declare that this research dissertation is my original work and has not been submitted for any degree at any other university or institution. The dissertation does not contain any other persons' writing unless specifically acknowledged and referenced accordingly.

Signed (Student): .... Date: 27 August 2022

DEDICATION

This dissertation was compiled during the darkest period of my life. My son Onndwela and my daughter Shudufhadzo, you became my shining light in my darkest moments, you gave me courage to wake up every day and thrive to do better and for that, I dedicate this dissertation to you both.

I love you both with all my heart.

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ABSTRACT

Availability of natural resources for the generations to come depends on the current state of harvesting as well as use patterns. Such anthropogenic activities impact on the species survival and functioning of ecosystems. Harvesting of plant species that exudates gum, resins and/or latex like *Spirostachys africana* Sond. dates as far back as the Middle Stone Age (MSA) period. The demand for ethnobotanical use of plant material particularly tree is continuously increasing particularly in developing countries. This leads to unsustainable and uncontrolled extraction of plant material, involving excessive debarking, felling of the entire trees, root harvesting, and other activities that are currently threatening plant species and indigenous forests. These unfavourable practices mostly lead to most species being threatened. This study investigated ethnobotanical use of *S. africana* by the *Vhavenda* at *Ha-Matsa* village in Vhembe district, Limpopo province, South Africa. This was achieved through interviewing informants using a semi-structure questionnaire. The study further investigated population structure of *S. africana* and how harvesting is affecting the population of this species. The ethnobotanical data collected showed that various parts of *S. africana* (mainly branches, bark and stem) are harvested for various uses by *Vhavenda* of *Ha-Matsa* village. The study further revealed that the *S. africana* population at *Ha-Matsa* village is mainly represented by high number of sub-adults and that this population is failing to recruit seedlings. Lack of seedlings was ascribed to high percentage of crown harvesting and other anthropogenic activities such as manmade fires observed in this study. Furthermore, the basal stem diameter exhibited a bell-shaped distribution curve suggesting that the *S. africana* population at *Ha-Matsa* village is unstable.

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INTRODUCTION

1.1 Background

The interaction of plants and humans is so strong that it can never be separated (Amjad *et al.,* 2015), as a result, plant resources have remained and will remain a major part of human society throughout history (Jima and Megersa, 2018). To study this important relationship, a scientific concept of ethnobotany was established in the 1800s, and it focussed on the connection which exists between local communities and their environment (Chavda *et al.,* 2022). This relationship extended to practices and cultural beliefs that are associated with different kinds of plant use (Amjad *et al.,* 2020). Ethnobotanical studies document indigenous/traditional knowledge of how people identify, classify, perceive, and relate to plants (Ugulu, 2011). These studies are broadly viewed as cultural studies of how people understand their plants, name them, utilize them, and arrange their information (Amjad *et al.,* 2015). However, new approaches towards the management of natural resources have been prioritized over indigenous natural resource management systems. Significant impacts on the environment have since been observed because of the neglect in utilization and application of indigenous knowledge systems in conservation of natural resources (Chepkosgei and Jerotich, 2016). Traditional ethnobotanical knowledge is therefore the major resource of most ethnobotanical investigations. Such knowledge which is important in the conservation and use of biological resources and should therefore be carried out before such rich heritage is destroyed due to several anthropogenic and other several natural causes (Ugulu, 2011). Ethnobotanical studies play a major role in highlighting the value of native plant species, future research, and potential development of new drugs (Amjad *et al.,* 2020). Whilst ethnoecological studies, provide integrative understanding of beliefs, knowledge and practice of a given social entity, and assist with comprehensive understanding of landscape use and management (Toledo, 2005).

The study by Chepkosgei and Jerotich (2016) established that indigenous knowledge and modern natural resource management strategies complement each other rather than being regarded as fundamentally incommensurable. The differences between the two systems can therefore be settled through collective natural resource management approaches that includes indigenous knowledge. These studies are important in flagging out the importance of native plant species and they consider traditional knowledge, mostly held by rural communities (Kayani *et al.,* 2014). With youth showing little or no interest in traditional knowledge, this body of knowledge on plant species within traditional healers and old members of the communities is rapidly decreasing (Amjad *et al.,* 2020). Therefore, there is huge risk of losing indigenous knowledge (Vitalini *et al.,* 2013) particularly on the use of natural resources. Wanjohi *et al.,* (2020) highlighted the importance of documenting indigenous ethnobotanical knowledge particularly in rural areas before it gets completely lost. Creating awareness among the youth and professionals on the importance of using indigenous knowledge can also assist to conserve and integrate indigenous knowledge in natural resource management sector. Creation awareness can be fulfilled through showcasing and promotion of cultural events and important aspects within the communities at various levels of practice. Some of the levels to be considered should include rites of passage, popular folk media, rituals, taboos, proverbs, songs and tomes (Chepkosgei and Jerotich, 2016).

The Rio Declaration, United Nations Scientific Conference Organisation (UNESCO), International Council for Science Union (ICSU) blueprint documents, Convention on Biological Diversity (CBD), and the documents emanating from the World Summit on Sustainable Development appreciated the role played by indigenous knowledge systems in biodiversity conservation (Shisanya, 2017). Member states to CBD are expected and encouraged to promote the utilization of indigenous knowledge systems when managing their natural resources. They should also accommodate and increase the use of indigenous knowledge systems and promote equity and access to benefit sharing resulting from its use (Shisanya, 2017).

Between 60 to 80% of developing countries, rely on economical and safe alternative plant-based medicines (Martins, 2014). In addition, between 30 to 50% of the population in developed countries like China, Germany, Australia, the USA, and France extensively using herbal remedies as supplementary health care (Amjad *et al.,* 2020), thus harvesting of natural resources particularly plant material for ethnobotanical uses is global phenomenon.

In South Africa, indigenous trees have always provided rural communities with firewood, building material, medicines, repellents, cosmetics, dyes, perfumes, food, and beverages (Van Wyk and Prinsloo, 2019). Multi-purpose tree species have therefore contributed towards the livelihoods of rural communities. Plant parts such as barks, roots, fruits, and seeds of various South African indigenous tree species are harvested for use as medicines, food and/or beverages (Van Wyk and Prinsloo, 2019). The woody parts of such convenient trees are often used as building material or firewood, or in carving of household products. Use of plants particularly for medicine, construction and crafting around the Venda region is vast (Sigidi *et al.,* 2016).

Like many other anthropogenic disturbances harvesting on plant material contributes towards shaping population structure of plant species being harvested (Bakali *et al.,* 2017). Effects of harvesting are usually driven by factors such as the plant part harvested, life history of species, season of harvesting, as well as intensity of harvesting and the local context thereof (Soumya *et al.,* 2019).

Recording of ethnobotanical data is therefore not only important for the documentation of indigenous traditions and the wealth of such heritage, but also shares insight on information necessary to understand how sustainable natural resources are being utilised, protect natural habitat in a long term, and give effect to a need of population ecology studies (Ugulu, 2016). There is an understanding in the field of natural resource management that traditional ethnobotanical knowledge within indigenous communities can positively shape and drive land management practices that are sustainable (Shisanya, 2017). Furthermore, traditional ethnobotanical knowledge can widen the way environmental problems are conceptualized and solved by communities, thereby strengthening a socioecological system's endurance (Wanjohi *et al.,* 2020). Ethnobotanical studies are therefore important to establish if harvesting has potential effects on plant communities (Botha *et al.,* 2017). This assists in paving way for the development of sustainable harvesting strategies as well as development of conservation options of various species (Soumya *et al.,* 2019).

1.2 Description of *Spirostachys africana*

Spirostachys africana Sond. (*S. africana*) is a hardwood medium-sized, deciduous tree species that belongs to family Euphorbiaceae. It has a round canopy that grows to a maximum height of between 10 and 20m tall (Lennox, 2019). Figure 1.1 below show an adult *S. africana* with a round-like canopy.

Figure 1.1: *Spirostachys africana* adult tree (Photo: M.V. Phalanndwa, 2021).

Like many other species within family *Euphorbiaceae*, *S. africana* produces a very poisonous and purgative milky latex that comes out from all its parts; i.e. bark, wood, stems and leaves (Lennox and Bamford, 2015). This tree has a very characteristic dark brown to black bark (Figure 1.2) that is rough, thick, and neatly cracked into regular rectangular blocks (Lennox and Bamford, 2015).

Figure 1.2: Distinctive stem bark of *Spirostachys africana* (Photo: M.V. Phalanndwa, 2021).

The heartwood of *S. africana* is brown to dark brown in colour with darker markings and streaks, and it is distinctly demarcated from the whitish to pale yellow sapwood. The tree flowers in spring to early summer before the new leaves appear. Fruits produced by this tree are eaten by birds, antelope and monkeys which helps with dispersal of seeds (Lennox, 2016). *S. africana* grows very slowly from both seeds and cuttings (Gandiwa *et al.,* 2012). The species occurs in clumps, and sometimes forming a characteristic pure dense stand of its own woodlands (Naidoo *et al.,* 2012).

Spirostachys africana is endemic to southern, central and east Africa (Beach *et al.*, 2010) as shown in figure 1.3. It is commonly found in deciduous woodland and wooded grassland, usually on termite mounds, stony slopes, and sometimes in thickets (Gandiwa *et al.,* 2012).

The largest trees are commonly found near water streams and seasonal watercourses since they prefer well-drained sandy or sandy loam soil. Nevertheless, the tree is commonly known to be resistant to drought and frost, but it responds very slowly to disturbance such as fire, cutting and/or browsing (Gandiwa *et al.,* 2012).

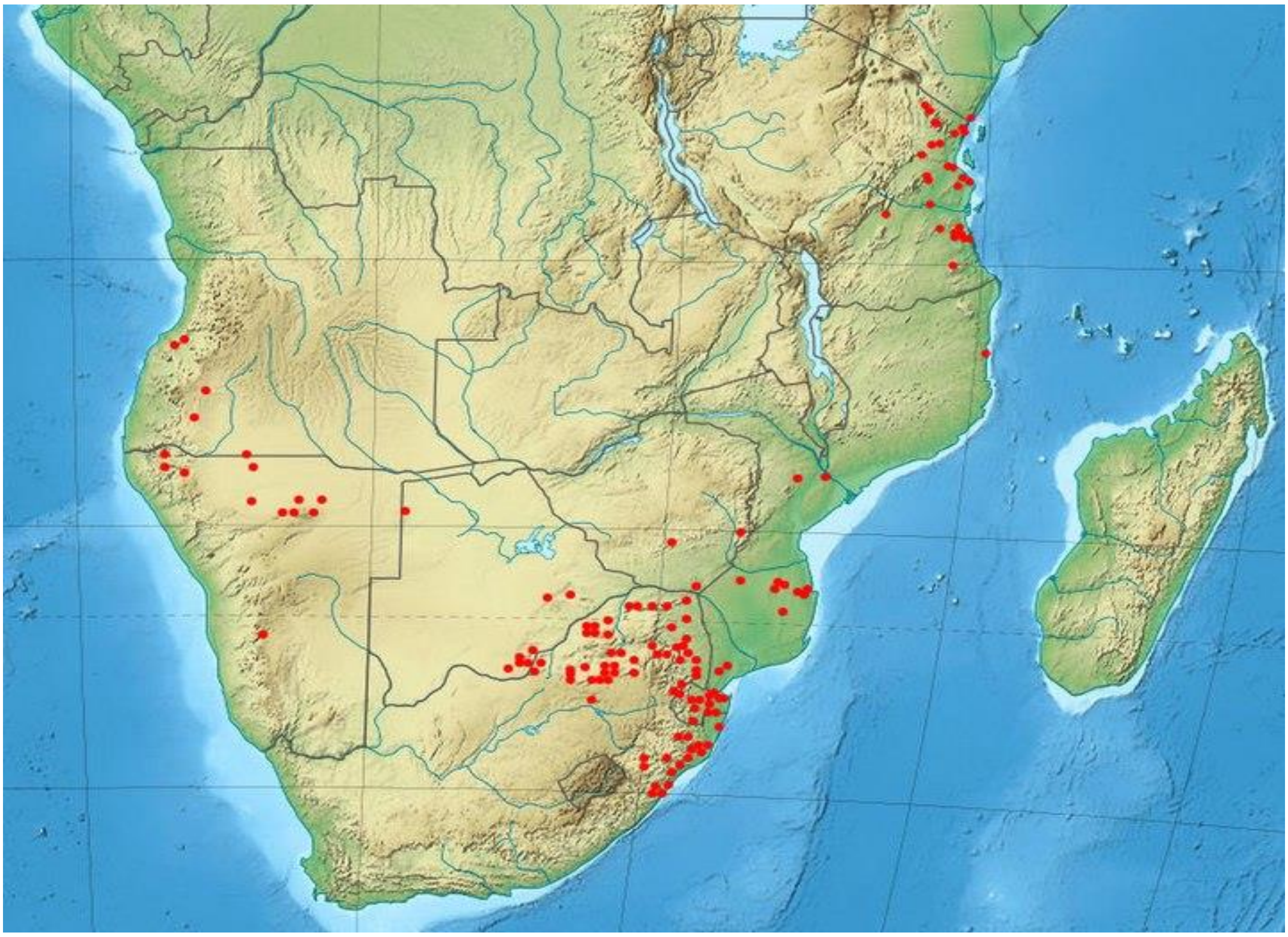

Figure 1.3: Distribution map of *Spirostachys africana* across the African continent (Image: Wikipedia).

Its use for medicinal purposes, and anti-repellent activities have been reported as far back as middle stone age period (Lennox, 2019;).

1.3 Problem statement

Continuous availability of natural resources for the generations to come largely depends on harvest and use patterns thereof. Impact of such activities on the species may influence the survival and functioning of ecosystems (Deepa *et al.,* 2018). For thousands of years' indigenous plants were used to treat and cure diseases, improve the health and well-being of humans (Hilonga *et al.,* 2019). Most of these plants are the basis of accessible and affordable health care system and form an integral source of livelihoods of indigenous and rural communities (Karunamoorthi *et al.,* 2013). Apart from use of indigenous trees for medicinal purposes, they have also been used for construction of shelters, for religious and other purposes (Mmolotsi *et al.,* 2012). As a result, concerns about sustainability of harvesting of indigenous trees has become more and more prominent. Unsustainable extraction methods which often involve excessive debarking and felling of the entire trees are currently threatening certain plant species and ultimately indigenous forests (Williams *et al.*, 2013). This is attributed to the fact that the demand on natural resources has become so high that these unfavourable practices are becoming more common (Alvarez and Hening, 2019). The increase in demand is partly influenced by an increase in subsequent trade of medicinal plant materials in most cases (Tshisikhawe, 2012). On the other hand, many rural communities are still highly relying on their immediate surroundings to sustain their livelihoods (Bakali *et al.,* 2017). These overreliances on natural resources together with rapid human population increase, increase in medicinal plant trade and other natural factors usually lead to biodiversity loss globally (Botha *et al.,* 2017).

Most studies suggest that *S. africana* is one of the tree species that faces harvesting for multiple purposes or uses, thus possibilities that this species may be exposed to unsustainable harvesting exist (Corrigan *et al.,* 2011). Observations made at the identified study area (*Ha-Matsa* Village) suggest that harvesting of *S. africana* continues to occur. However, no detailed ethnobotanical and population ecology studies have been conducted exclusively for *S. africana* particularly in the Vhembe region. According to the IUCN red list there is data deficient on *S. africana* and the species is listed as a species of least concern. Therefore, there is a need for ethnobotanical profiling (uses, harvesting regimes, etc.) of this species. Furthermore, there is a greater need to establish if harvesting has impact on population structure. This can contribute significantly towards the development of sustainable management and conservation strategies for this species.

1.4 Aim and objectives of the study

In line with the context of the problem statement, the main aim of this study was to establish the ethnobotanical use of *S. africana* by *Vhavenda* as well as assessing the population structure of this species in the presence of harvesting. This was achieved by investigating the following objectives:

(i) Profiling the ethnobotanical utilization of *S. africana* by the *Vhavenda* in *Ha-Matsa* Village,

(ii) Assessing population structure of *S. africana* and impact harvesting has on this species.

1.5 Hypothesis

The hypothesis put forward in this study was that harvesting of *S. africana* for different purposes by *Vhavenda* of *Ha-Matsa* village has a negative effect on its population structure.

1.6 Structure of dissertation

Each objective of this dissertation is presented as a free-standing chapter. It is therefore unavoidable to repeat certain information in the some of the chapters. The first chapter deals with background of the research topic, introduction of the species under study, rationale, aim and objective of the study as well as the hypothesis thereof. The second chapter covers the ethnobotanical utilization of *S. africana.* Chapter 3 deals with the ecological aspect on the population structure of the species. The summary, general conclusion and recommendations of the study are presented in chapter 4.

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Chapter 2

ETHNOBOTANICAL STUDY OF *Spirostachys africana* SOND. AT *HA-MATSA* VILLAGE, LIMPOPO PROVINCE, SOUTH AFRICA

2.1 Introduction

Species in the Euphorbiaceae family are very popular for their poisonous, white, milky latex. Most of the species in this family have been used for various ethnobotanical purposes in most parts of the world (Lennox, 2019). Latex is understood to provide plant defence mechanisms by discouraging browsing animals and insects, as well as eradication and controlling of the subsequent growth of microbial phytopathogens, as well as sealing of wounded areas (Spano *et al.,* 2012). Harvesting of plant species that exudates gum, resins and/or latex for traditional medicine, pharmaceutical products, ritual, food and in several other technical applications dates as far back as two BC (Mwine and Van Damme, 2011). Lennox (2016) also found evidence that *S. africana* has been used for ethnobotanical botanical purposes since the Middle Stone Age (MSA) period. During this period (MSA) *S. africana*'s wood was used for its aromatic smoke that could have possibly been burnt for medicinal purposes (Lennox, 2019). Chaboo *et al.,* (2019), indicated that *S. africana* has been used for over 77 000 years for its wood with toxic properties to repel insects.

Spirostachys africana is utilised in the woodcraft industry (Naidoo *et al.,* 2012) and has various medicinal uses (Mathabe *et al.,* 2008). The latex of *S. africana* contains class of chemical compounds that are purgatives (phorbol esters) and known to induce diarrhoea (Mavundza *et al.,* 2018). Phorbol esters extracted from latex also have characteristics that promote hair growth, eliminate freckles, warts, and skin ulcers (Mhlongo and van Wyk, 2019; Prinsloo *et al.,* 2018). Root and stem bark of *S. africana* are used for emetics (to induce vomiting), purgatives (constipation relief), painkiller and vermifuge (antiparasitic drug that is used to expel parasitic worms and other internal parasites from the body (van Wyk and Prinsloo, 2019). *S. africana* is also used to promote weight loss and treatment of spell (*idliso*) as well as for treating snakebite (Mhlongo and van Wyk, 2019). Akhalwaya *et al.* (2017), found that organic extract of *S. africana* leaves contained high antimicrobial activity suitable to treat *Candida albicans* (a fungal infection caused by yeasts commonly found in gastrointestinal tract and mouth of humans). In this study the leaves extract was also found to contain anti-adherent properties suitable to treat tooth decay caused by bacterium *Streptococcus mutans*. Antifungal and antioxidant potential of *S. africana* may have great potential as possible leads in the development of biofungicides that may assist in prevention of oxidation related food spoilage (Dikhoba *et al.,* 2019). Historically the species has been reported to be used in treatment of wounds and other related conditions (Direko *at al*., 2019).

Concoctions of its roots, barks and the latex have been utilized in treatment of various medical conditions for centuries. The wood is popular for its durability and has been used for decorative joinery, furniture, cabinetry, flooring, shipbuilding, musical instruments, carvings, turnings, small specialty items, fuelwood construction posts as well as beams. Latex provides plant defence mechanisms which repel browsing animals and insects, and it also controls the growth of microbial phytopathogens, and sealing of wounded areas (Spano *et al.,* 2012).

In the Sub-Saharan African countries such as Namibia, Angola and Zimbabwe, the white milky latex of *S. africana* is known to make a good poison for compound arrow and fishing (Chaboo *et al.,* 2019). In South-Central Zimbabwe the roots of *S. africana* were found to be used for making herbal preparations and root powder mixed with porridge are used as medicine for venereal infections (Maroyi, 2013). In Tanzania, the stem barks and roots are used in treatment of cervical, breast, colon, and liver cancer (Direko *et al.,* 2019). In Botswana, the species is valuable for its timber that is durable, strong, attractive and used for household construction, local furniture, and fencing (Mmolotsi *et al.,* 2012).

In the Eastern Cape South Africa, powder made from the roots of *S. africana* is used to treat sexually transmitted infections such as venereal infections (van Vuuren and Naidoo, 2010). Xhosa women use seeds and macerated powdered bark to treat skin rashes, pimples and to remove spots on the skin (Mingwa *et al.,* 2019). In addition, Xhosa people also use traditionally prepared residue of this species to treat infantile cradle cap commonly known as *'ishimca'* (Nieman *et al.,* 2019). In Kwazulu-Natal, *S. africana* is used for dermatological purposes such as treating lice and hairdressing (Mhlongo and van Wyk, 2019). The *Vhavenda* use the species smoke to fumigate their traditional huts against wood-boring and other unwanted insects (Lennox and Bamford, 2015).

2.2 Study area, materials, and methods

2.2.1 Study area

This study was carried out at *Ha-Matsa* village located in Makhado local municipality, within the Vhembe district in Limpopo province, South Africa (Figure 2.1). The village is found within a savannah biome with predominantly a mix of Lowveld and Bushveld vegetation types. The area is represented by semiarid climatic zone with dry, cold winters and hot, wet summers and experiences periodic droughts.

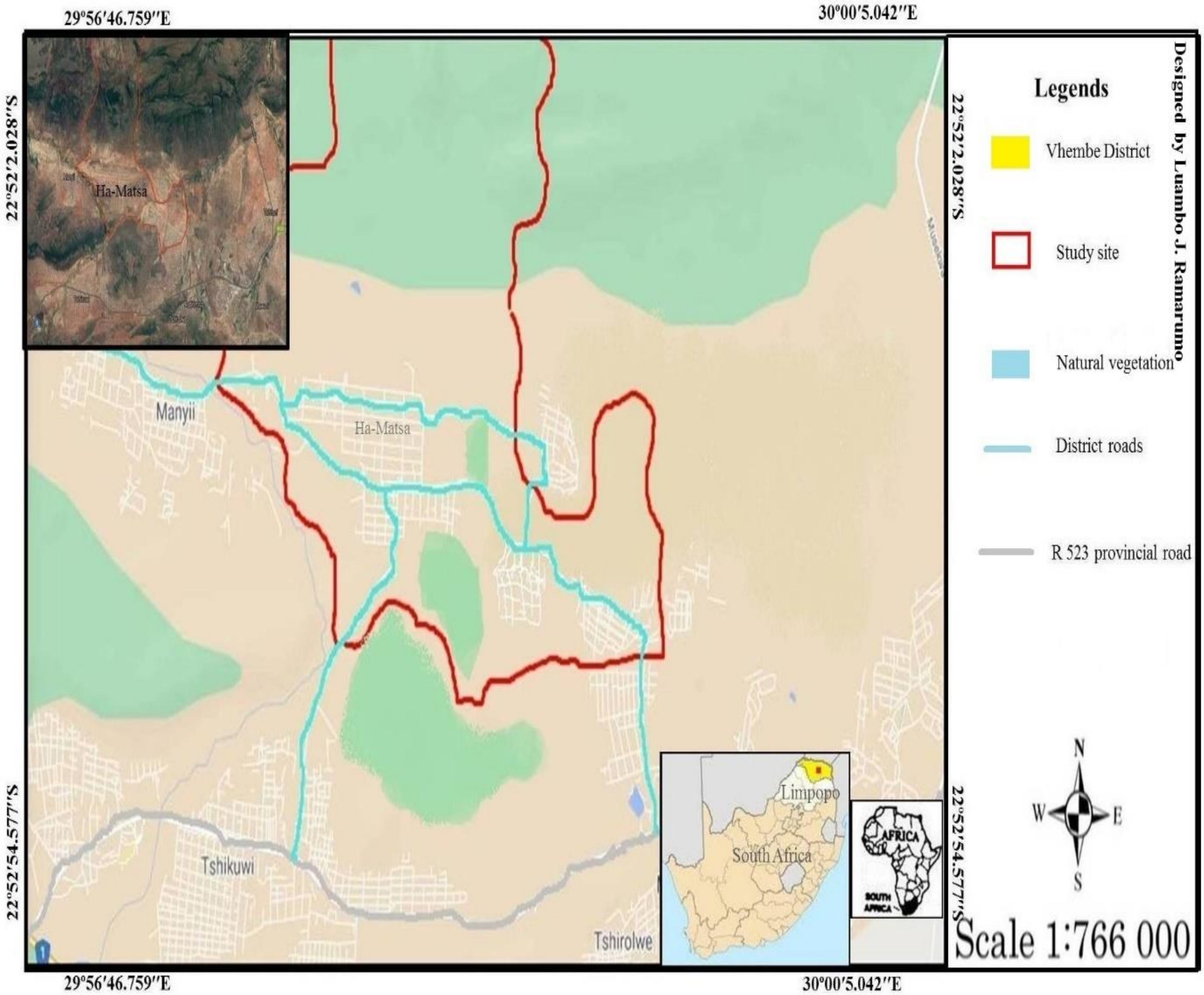

Figure 2.1: A map of study area located at *Ha-Matsa* village.

According to 2011 Census data, population size of this area was estimated at 2670, with about 64% of the population over the age of 14 years old and about 59.5% of households that are headed by woman). About 99.9% of the population is African, predominantly *Vhavenda* (STATSSA, 2011*)*. Residents of this area mostly depend on small scale, non-commercial agricultural and farming activities. Residents of *Ha-Matsa* village are still heavily reliant on natural environment for ecosystem services such as provisioning of water, firewood, traditional medicine etc. The closet primary healthcare facility is situated over 5km away at Tshikuwi village.

2.2.2 Methodology

Prior to collection of data, consent to conduct the study at *Ha-Matsa* village was acquired from the local Chief of the area. Before conducting interviews, the aim of the study was clearly explained and consents from all informants were acquired. To identify suitable informants, a convenient non-probability random sampling technique was used. This was done through door-to-door visits and approaching potential informants on the streets. To identify if potential informants were eligible to form part of the study they were asked if they either know or have knowledge of *S. africana* and its uses. Those who indicated that they do not know or do not have knowledge of *S. africana* were not invited to participate further. However, age group for those that indicated that they have no knowledge of the species was recorded. This was done to identify how lack of indigenous knowledge is distributed amongst different age groups.

Following identification of suitable informants, a semi-structured questionnaire (Annexure A) was used to collect ethnobotanical information from each informant. The questionnaire, interviews and discussions were conducted in Tshivenda. Information was captured in the survey forms in both Tshivenda and English languages. Information captured in Tshivenda was later translated into English language and all data was captured into Microsoft Office Excel (MS. Office Excel). Information collected included names used for the targeted species, preferred parts harvested and used, uses of parts harvested, preferred season for harvesting, and perception on availability of the species. In addition, age, gender and educational background of informants was also collected. Data from all the interviews was analysed using descriptive statistical analysis on Microsoft Office Excel programme.

2.3 Results and discussion

2.3.1 Informants' profile

a Sex

A total of 69 informants with significantly high participation by females contributing 77% (n=53) of the sample size and a significantly low contribution of 23% of the sample size by males (n=16) were interviewed for this study. Figure 2.2 shows number of informants interviewed amongst different gender groups. This higher percentage of participation by female informants can be associated with the 2011 Census data of the *Ha-Matsa* village. About 59.5% of households in this village are headed by women while men travel to the Cities to look for employment (STATSSA, 2011). The latter therefore explains why more female informants were found compared to male.

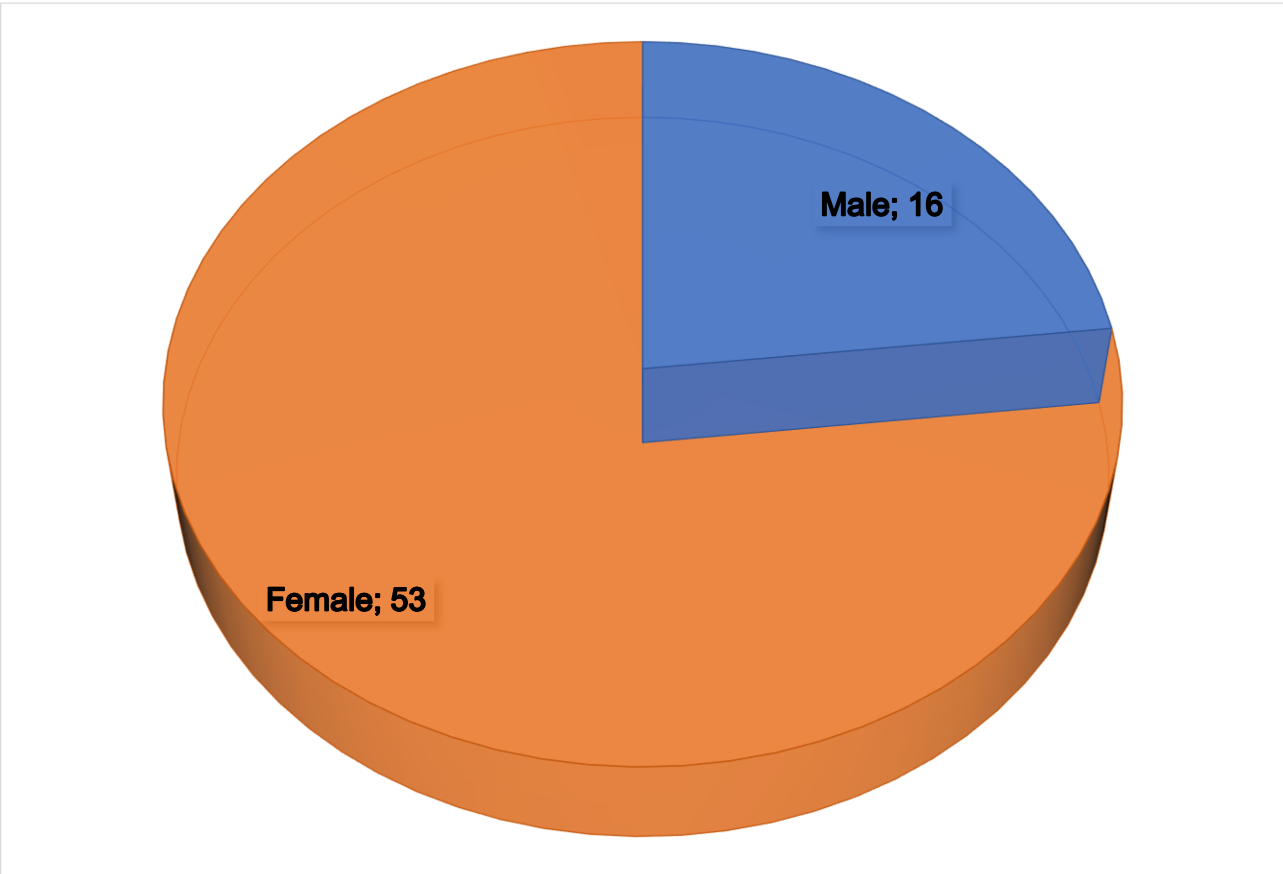

Figure 2.2: Sex profile of informants interviewed in the study.

Amongst different sex groups, a total of 49 informants indicated that *S. africana* can only be used a single purpose. On the other hand, a total of 15 informants indicated that this species can be used for more than one purpose. Figure 2.3 indicate the number of informants amongst different sex groups that indicated that *S. africana* has single versus multiple uses. The percentage difference of about 25% was found between numbers of male informants that indicated that *S. africana* has single use compared to those that indicated that the species can be used for multiple purposes. There was a noticeably high percentage difference (57%) in number of females that indicated that *S. africana* has single use compared to those that indicated that the species has multiple uses. In addition, proportional to the number of female informants interviewed in this study, females contributed a lot more information in relation to different uses of *S. africana* compared to males. A study conducted in Namibia (Cheikhyoussef *et al*., 2011) about indigenous knowledge on medicinal plant use by traditional healers also indicated or recorded high participation of women informants (70%) as it was also observed in this study. They associated this with the fact that women often consider traditional medicine first for the treatment of infertility or sexual related diseases than man as a result, women are mostly found to be more knowledgeable when it comes to indigenous knowledge. The current study also established similar pattern where many women in this study seemed to be more knowledgeable on the medicinal uses of *S. africana* as compared to women.

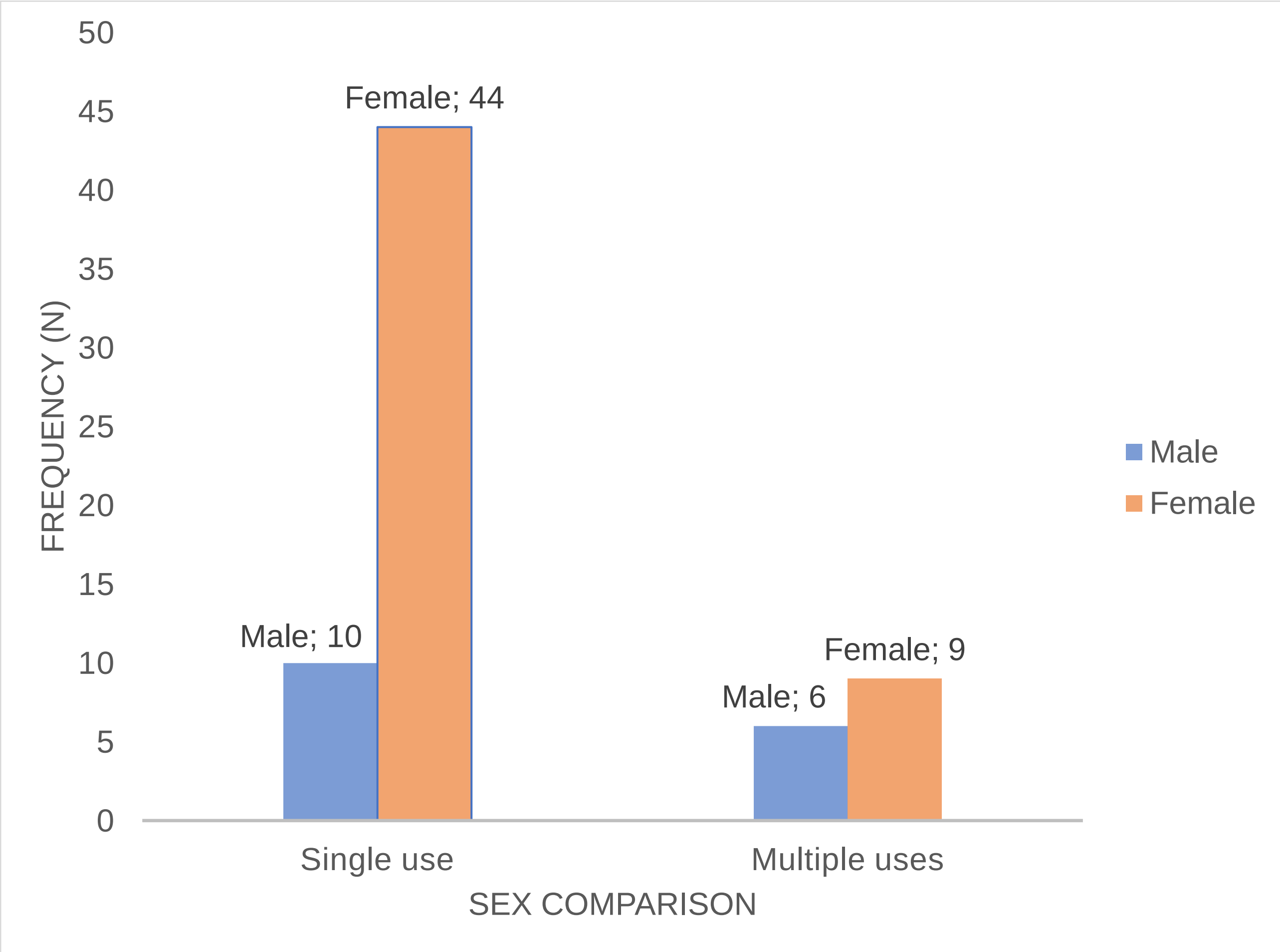

Figure 2.3: Comparison of informants that indicated that single vs multiple use of *Spirostachys africana*.

Survey data further shows no significant difference between number of informants (n=36) that indicated that single part is harvested versus number of informants (n=33) that indicated that multiple parts are harvested. Figure 2.4 shows a comparison of number of informants amongst different sex groups that indicated that only single part of *S. africana* is harvested and used versus number of informants that indicated harvesting and use of multiple parts.

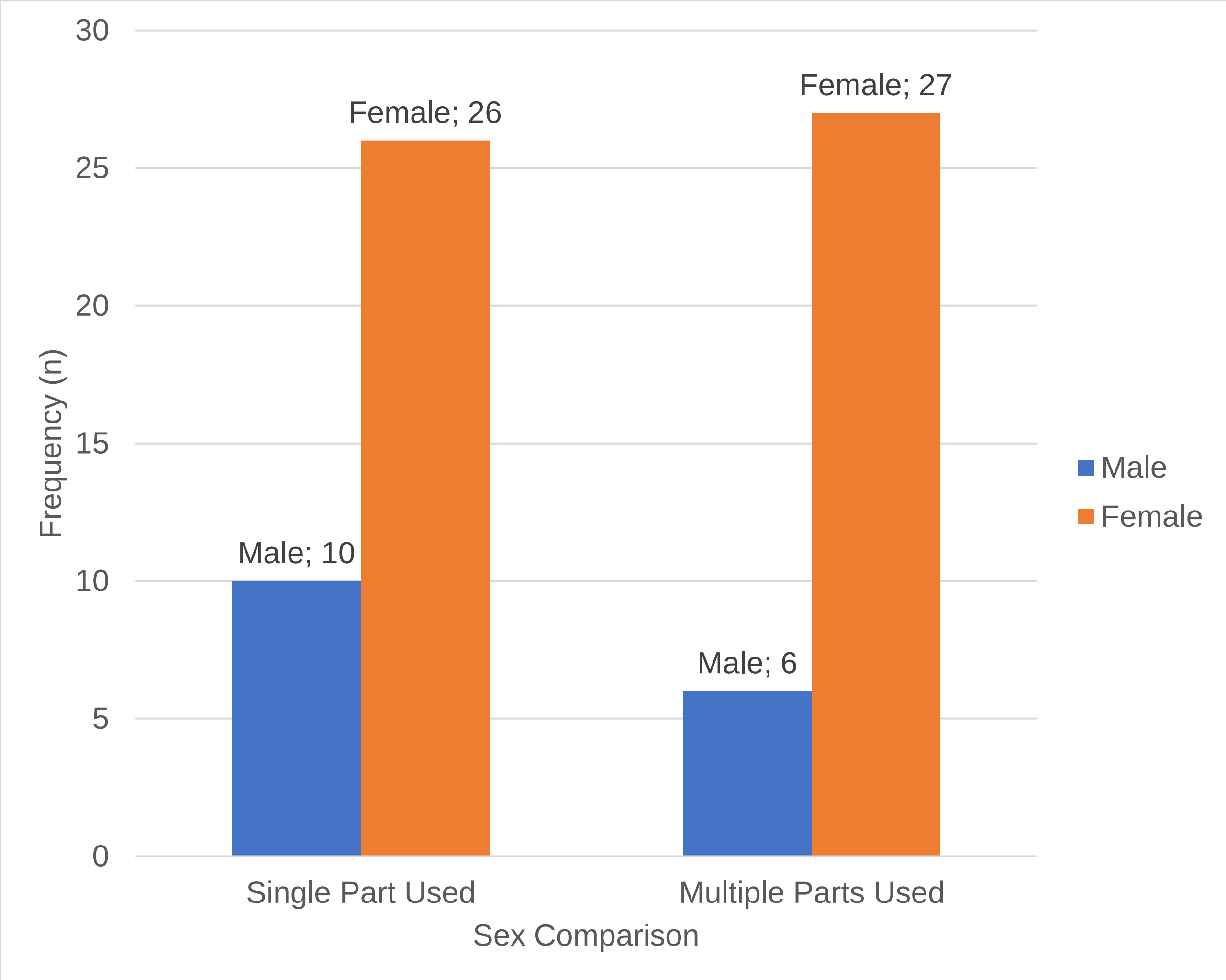

Figure 2.4: Knowledge of plant parts use frequency as per sex of informants.

b Age groups

Age profile of informants plays an important role in establishing use and application of indigenous knowledge associated with natural resources (Chepkosgei and Jerotich, 2016). Three age class groups of informants starting with youth (informants of ages below 36 years), then adults (informants of ages between 36 and 55 years) and elderly (informants over 55 years of age) that participated in this study were found. Adult and elderly informants contributed more in this study with each age group contributing 48% (n=33), and 43% (n=30) respectively. A significantly low contribution of 9% (n=6) by informants in the youth age group (persons under 36 years) was recorded (Figure 2.5). Cheikhyoussef *et al.* (2011) found that people older than 66 years of age had substantive indigenous knowledge. They related this pattern or distribution of indigenous knowledge to the fact that this kind of knowledge is conveyed from one generation to the next over time. Whilst Corrigan *et al.,* (2011), Vitalini *et al*., (2013), and Wanjohi *et al.,* (2020) all highlighted that modern youth is normally not interested on traditional knowledge. Similar pattern of distribution of indigenous knowledge amongst different age groups found on the above-mentioned studies was also observed in the current study. It is also important to highlight that during collection of ethnobotanical use data in the current study, all adults and elderly informants that were approached indicated that they have knowledge of *S. africana* and its use. Whereas a significant number of youths approached had no knowledge of the species nor its uses.

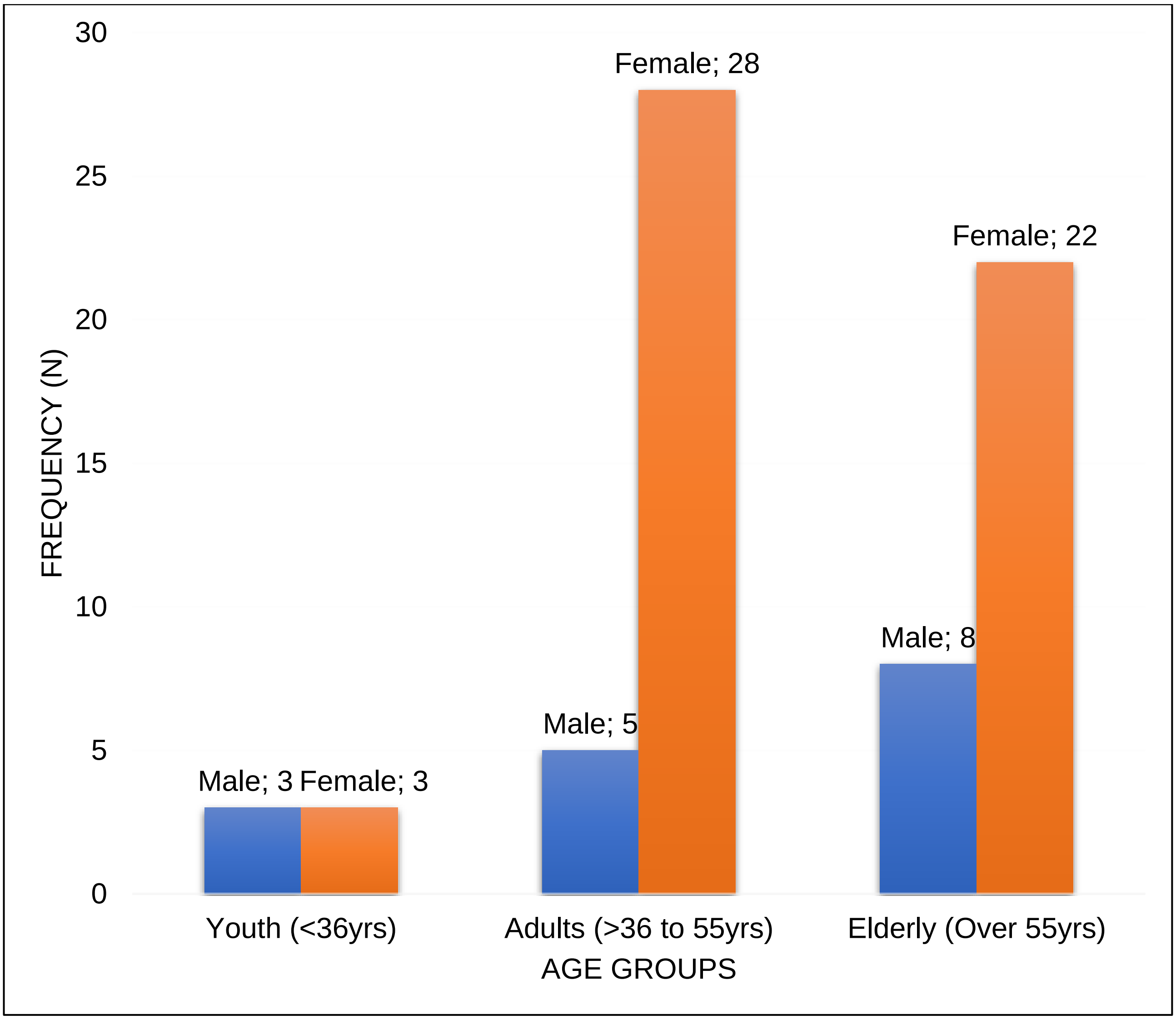

Figure 2.5: Distribution of *Spirostachys africana* knowledge amongst different sex and age groups.

Amongst all three age groups, total number of informants that indicated that multiple parts of *S. africana* are harvested and used are lower than those that indicated harvesting of single parts. Figure 2.6, details percentage comparison of informants in each age group that indicated that single part of *S. africana* is harvested and used versus those that indicated that multiple parts are used. There was no major difference found amongst different age groups with respect to single part versus multiple parts of *S. africana* harvested and used by *Vhavenda*.

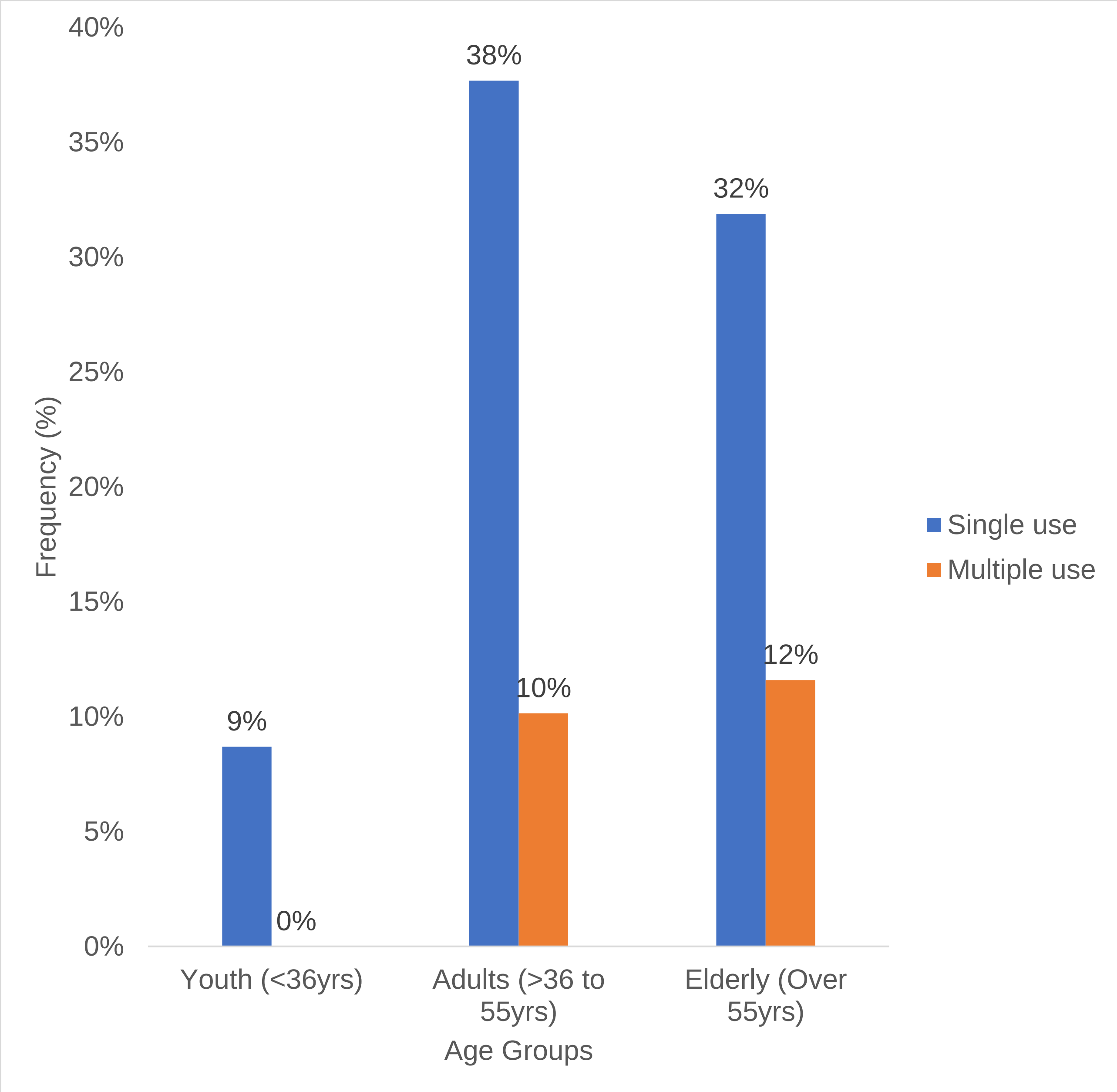

Figure 2.6: *Spirostachys africana* parts harvesting as per age groups.

All informants in the youth age group (n=6) interviewed in this study indicated that *S. africana* is harvested and used only for a single purpose. Thirty-eight percent of adult informants and 32% of elderly informants also indicated that *S. africana* is harvested on used only for a single purpose. Whereas 10% and 12% of informants in the adult and elderly age groups respectively indicated that *S. africana* has multiple uses. In relation to the total number of uses that were recorded in this study, informants in the adult age group were found to have contributed more uses than the other age groups. Figure 2.7 shows a breakdown of number of informants amongst different age groups that indicated that *S. africana* has single use versus those that indicated multiple uses. Significantly high number (n = 54) of informants amongst all three age groups indicated that *S. africana* only has a single use.

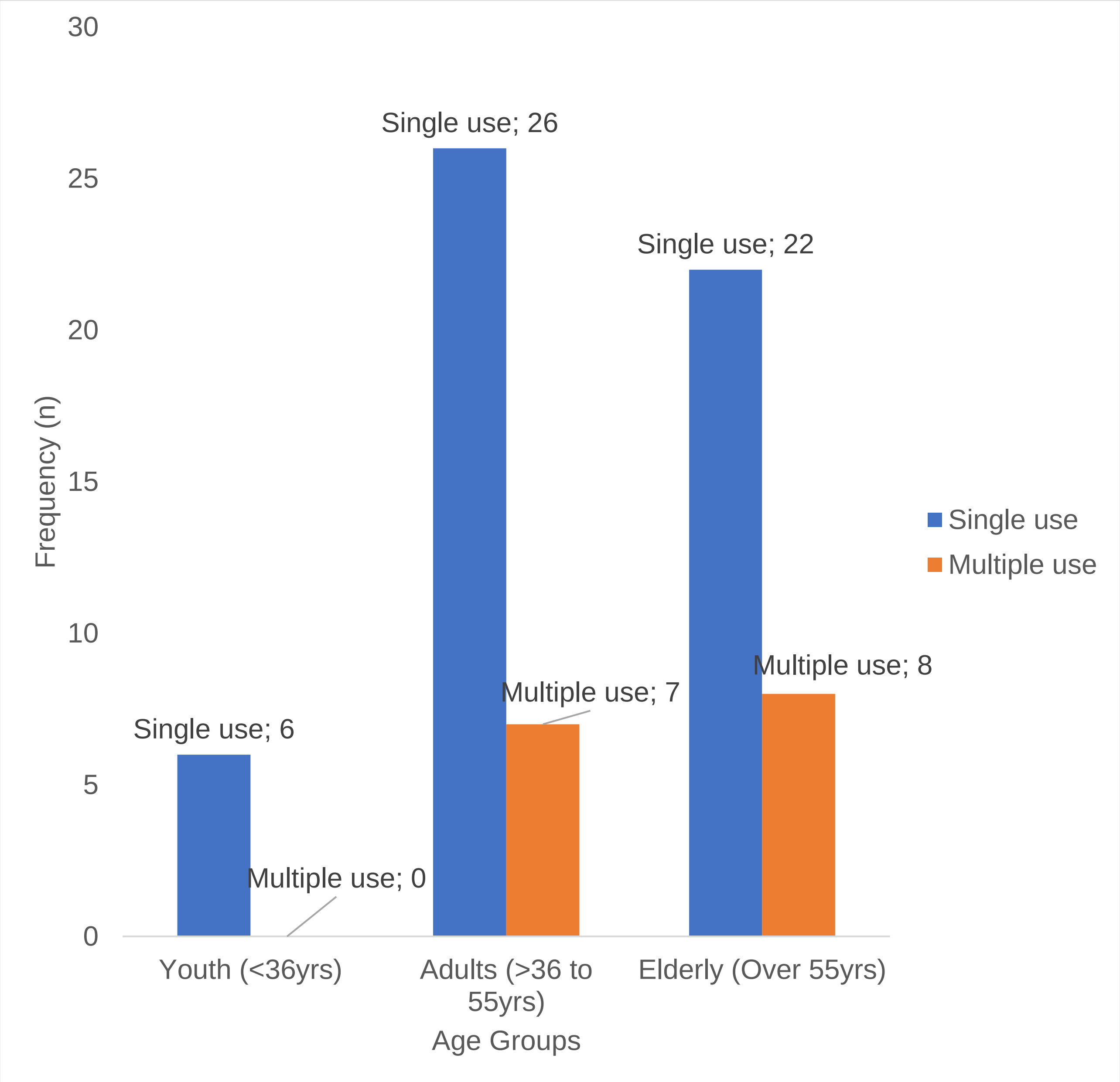

Figure 2.7: *Spirostachys africana* use frequency per age group of informants.

c Educational background

In addition, educational background information for all informants interviewed was also recorded to determine if there is correlation between distribution of indigenous knowledge and educational level. The survey data shows that 64% of informants were found to have received some form of formal education and the other 36% were found to be illiterate since they never received any formal education. Figure 2.8 shows a comparison between number of literate and illiterate informants per age group interviewed for the current study. Amongst the literate group about 23% had only received primary education while 64% received formal education up to secondary level, and the other 14% received formal education up to tertiary level. Amongst different sex groups, female informants had higher percentage of illiterate informants compared to male informants. Seventy five percent (75%) of literate informants and 72% of illiterate informants indicated that *S. africana* only has single use. Whereas 25% of literate and 28% illiterate informants indicated that *S. africana* has multiple uses. This therefore suggest that there is no noticeable difference in the distribution of knowledge about *S. africana* uses between literate and illiterate informants. Amjad *et al.,* (2020) found education to be third influential factor on the distribution of indigenous knowledge following sex and age respectively. It therefore makes sense that this study found no noticeable difference in the distribution of ethnobotanical knowledge of *S. africana*.

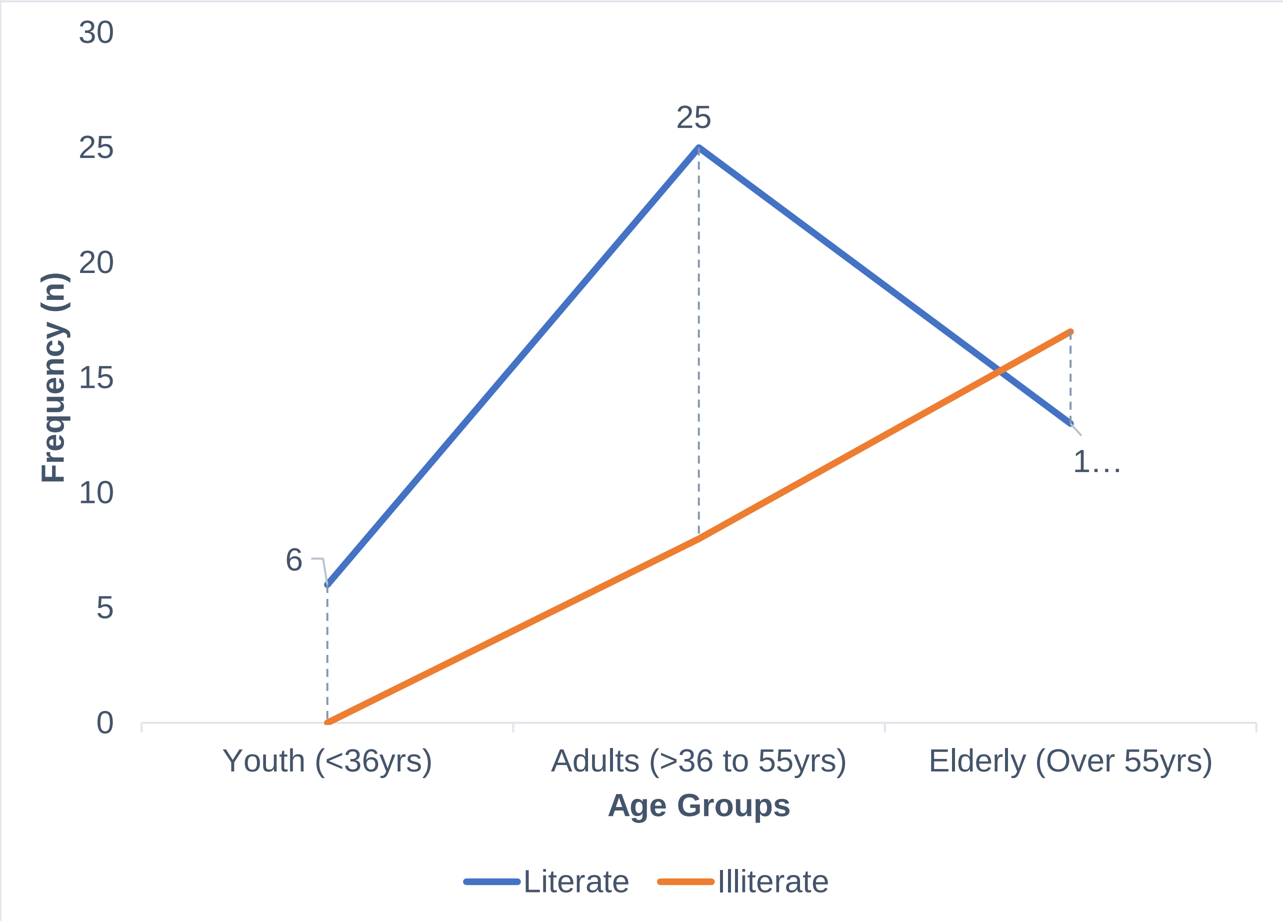

Figure 2.8: Distribution of informants' educational background per age groups.

2.3.2 Ethnobotanical profile of *Spirostachys africana*

Ethnobotanical use data collected during the surveys as well as observations made in the study area indicate that various parts/organs of *S. africana* have been and are still being harvested for various uses by *Vhavenda* of *Ha-Matsa* village (Figure 2.9). Several uses for *S. africana* were recorded and grouped into seven categories (Medicinal, building and construction, pesticide/anti-repellent, crafting and design, food and beverages, firewood, and infrastructure protection). Majority of informants indicated that the species is used for traditional medicinal. It is suggested that about 80% of the world population depend on traditional medicine particularly from plants for their primary healthcare needs and this is because traditional medicine is deemed an economical and safe alternative to the ofteninaccessible allopathic medicine (Sigidi *et al.,* 2017). The latter and the fact that the closest primary health care facility to the *Ha-Matsa* village is over five (5) kilometres away explains why such a high dependency on this species for traditional medicine. No preferred season or time of harvesting was recorded, and no clear indication of preferred class size harvested particularly for medicinal purposes. However, adult trees are preferred for uses such as building and construction as well as crafting.

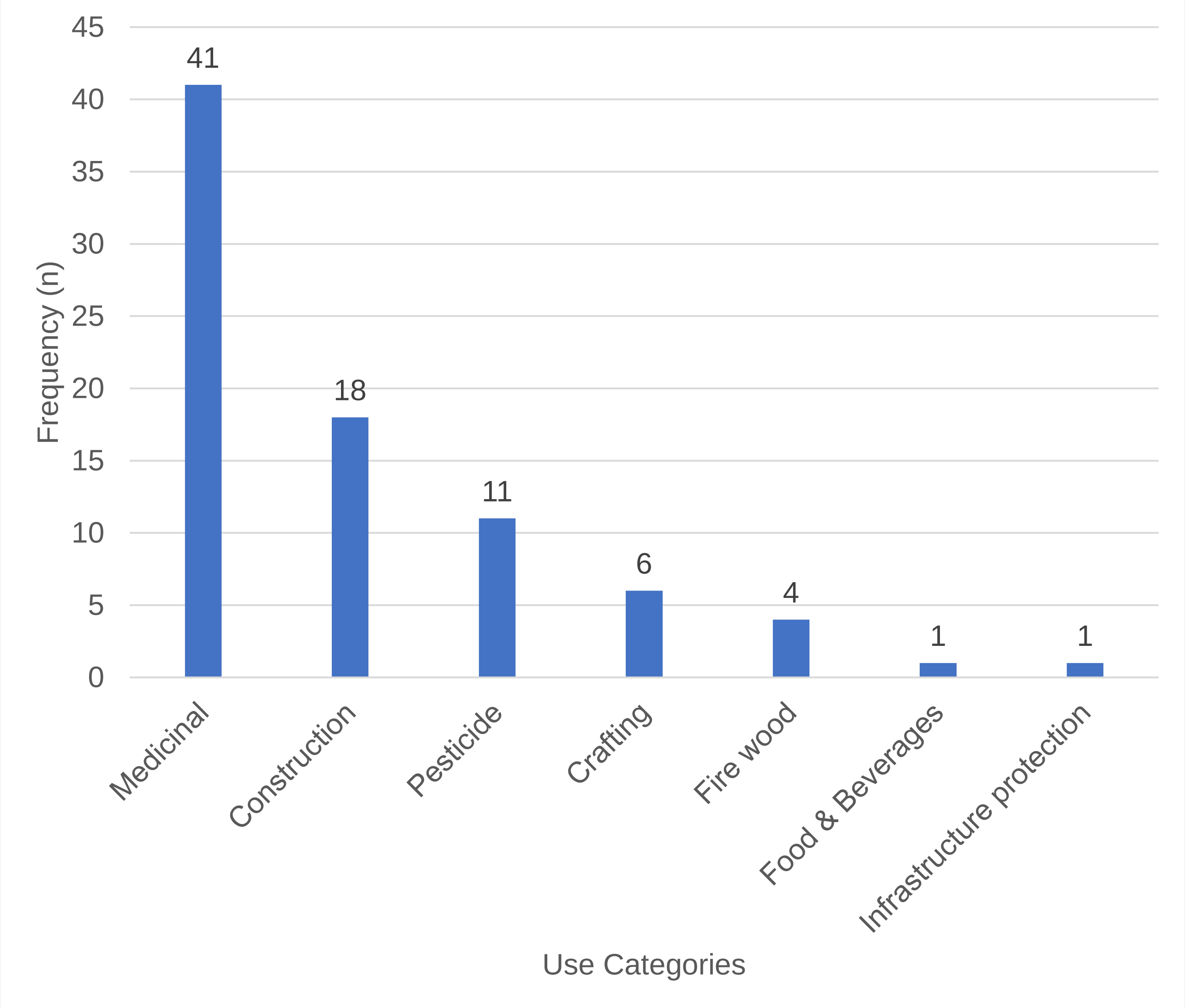

Figure 2.9: Frequencies of reported use categories.

a Medicinal uses of *Spirostachys africana*

A total of 41 (30 females and 11 males) informants representing 59% of informants interviewed indicated that *S. africana* is used for traditional medicine to treat various illnesses in human and livestock. High number of females (Figure 2.10) in this study were found to be knowledgeable about medicinal use of *S. africana.* Similar findings were also reported by Cheikhyoussef *et al.,* (2011) who found that women usually consider using traditional medicine first for the treatment of their infertility or sexual related diseases than man, thus they were more knowledgeable about medicinal use of plants compared to man. Whaley (2011) found that administration of traditional medicine by women to be a common phenomenon that is particularly done whilst taking care of the sick at home.

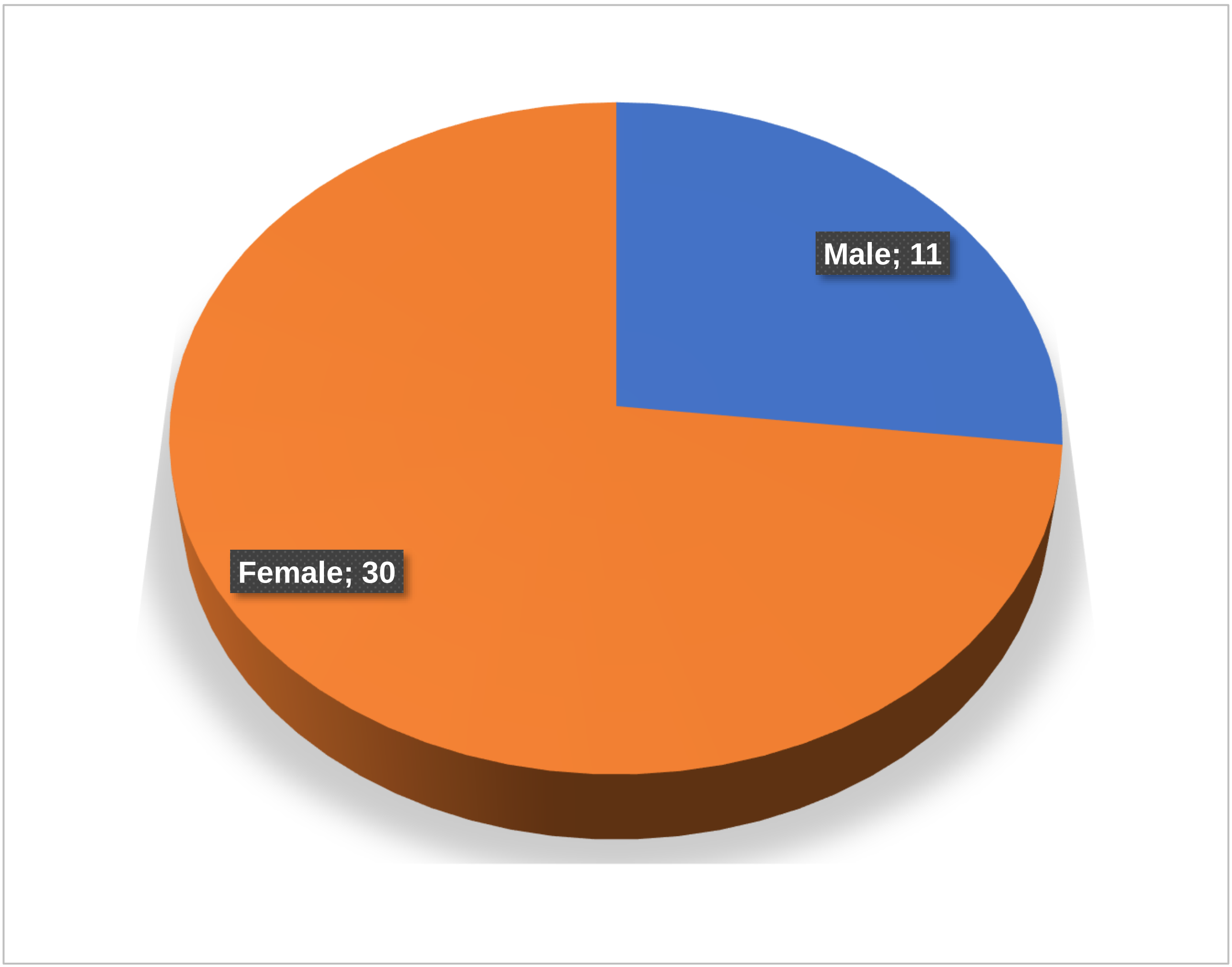

Figure 2.10: Frequency of informants that reported the use of *Spirostachys africana* for medicinal purposes.

Study by Singh *et al., (2020)* has found that *S. Africana* contains seven classes of phytochemicals (alkaloids, flavonoids, phenols, tannins, saponins, steroids, and terpenoids) in the stem, leaves, bark and root of the plant. These phytochemicals are known to provide health benefits for humans as medicinal ingredients. Morphine and ephedrine are some of powerful narcotic alkaloids found in S*. africana* that are known to be used to relieve pain, discomfort of common colds, sinusitis, hay fever and bronchial asthma (Coche *et al.,* 2016). This can be the reason why the current study reported a significant number of pain related illnesses (Figure 2.11) that *Vhavenda* of *Ha-Matsa* village uses *S. africana* for. Singh *et al., (2020)* further established that *S. africana* has a broad spectrum of biological activities, including antimicrobial, antibacterial, antidiabetic, antimalarial, antioxidant, cyanogenic, anthelminthic and larvicidal. Mavundza *et al*., (2018) reported that Zulus use the species to induce diarrhoea*.* The latter was ascribed *to a* class of chemical compounds (phorbol esters) that *S. africana* contains that are purgatives (Mavundza *et al.,* 2018). The current study, however, has found that *Vhavenda* of *Ha-Matsa* village use of *S. africana* uses for treatment of diarrhoea. This therefore prove that same plant can be used differently in different areas and by different tribes. Other medicinal use of *S. africana* recorded in this study included treatment of impotence and epilepsy. The latter medicinal uses including treatment of menstrual pains were not found in the literature reviewed for this study.

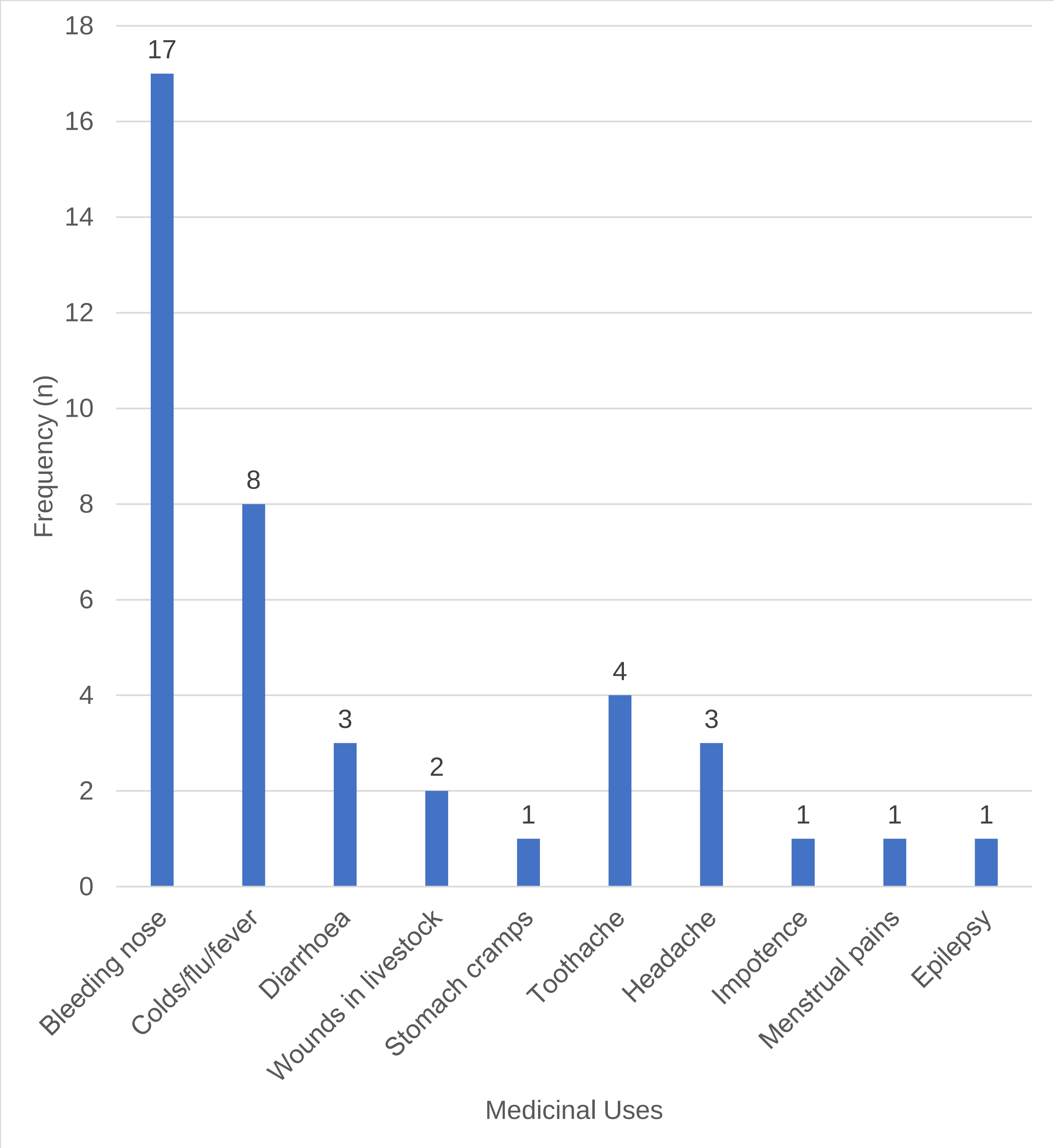

Figure 2.11: Figure 2.11: Medicinal use categories of *Spirostachys africana* recorded at *Ha-Matsa* village.

Mabogo (1990) found that the root or stem bark and the bark from the trunk are the most preferred parts used in traditional medicine. Magwede (2018) confirmed the medicinal use of *Spirostachys africana* bark by *Vhavenda* in addition he also found that seed oil, and wood of *S. africana* are also used in traditional medicine. Data from the current study also confirms findings by Mabogo (1990) and Magwede (2018) on the parts of *S. africana* used for traditional medicine except for the use of seed oil. In addition, the current study established that branches, leaves, and latex are harvested and used by *Vhavenda* of *Ha-Matsa* village for medicinal purposes as well. The use of stem bark (mentioned by 17 informants) and branches (mentioned by 16 informants) were found to be the most preferred parts used for medicinal purposes by informants of *Ha-Matsa* village (Figure 2.12).

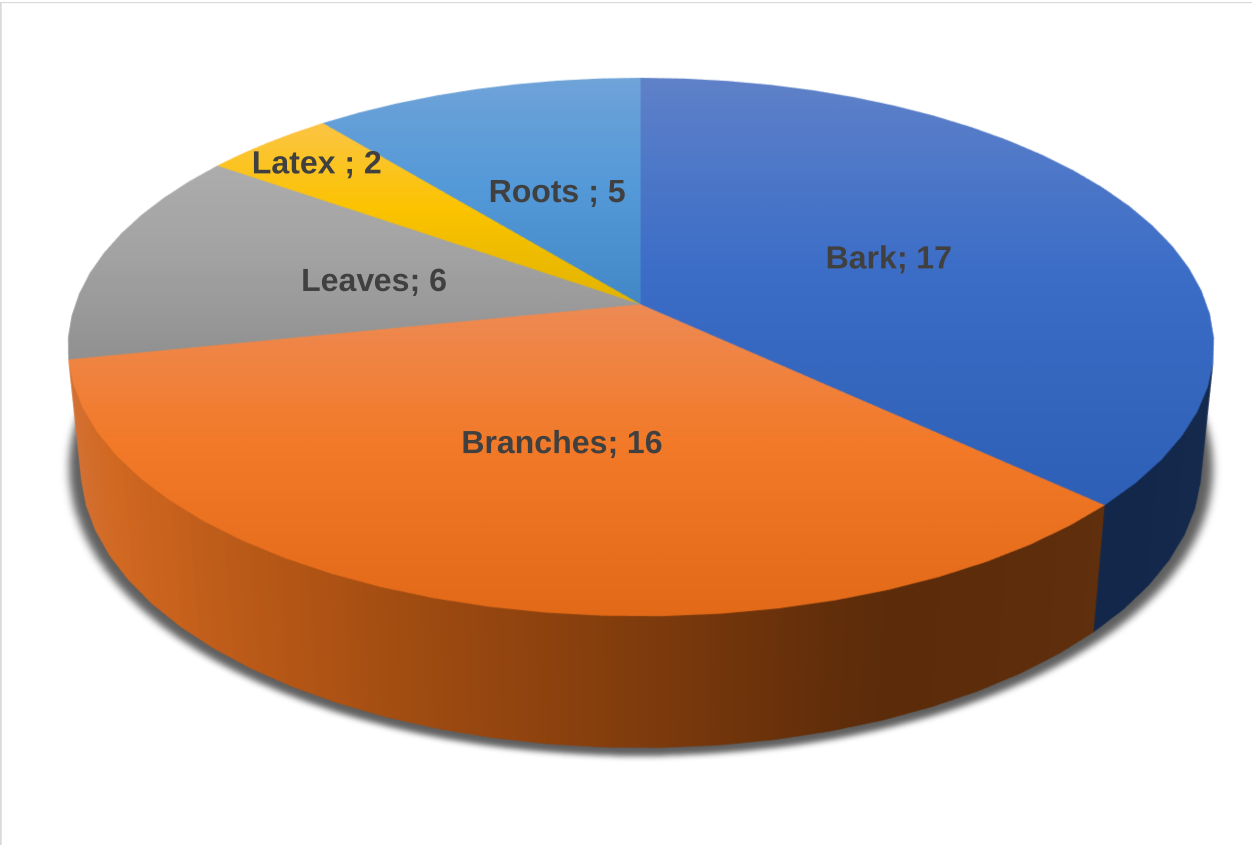

Figure 2.12: *Spirostachys africana* medicinal plant parts utilization profile.

b Building and construction

Spirostachys africana wood from both the stem and branches of adult trees is known to be strong and has anti-repellent properties which makes it suitable for building and construction (Spano *et al.,* 2012). Study by Mmolotsi *et al.,* (2012) found that in Botswana, *S. africana* timber is used for household construction, local furniture, and fencing. Luoda *et al.,* (2000) established that *S. africana* wood in Tanzania is preferred as wall erecting poles or beam poles because it is termite resistant. In the current study, it was established that stem and thick branches of *S. africana* are harvested for manufacturing of door frames, stabilization of pit toilets, erection of fence, construction of kraals and goat pens. In the current study, informants mentioned that thin branches (of about 30 mm diameter) are also harvested and used as droppers for fencing. The harvested materials are used raw immediately after harvested mostly for fencing. For uses such as, manufacturing of doorframes and stabilization of pit toilets, the trunk or thick branches are cut down and left to dry before used or the user target an already dead tree.

c Pesticides/Anti-Repellent

A total of 11 informants indicated that *S. africana* is used as an anti-repellent or pesticide. In addition, all 18 informants who indicated that the species is used for building and construction further indicated that apart from its wood being durable, the anti-repellent properties that this plant has makes the wood be more preferred for building and construction. Spano *et al.,* (2012), also highlighted that the latex from the species is commonly used as a defence mechanism that help in its maintenance. Interestingly, one informant indicated that in the olden days, this species used to be planted inside or around the kraal for the purposes of reducing/controlling flies and mosquitos. The heartwood of *S. africana* is harvested by complete cutting down of the whole tree and dissection of the trunk/stem before thrown into the bag/storage hut full of grain to repel weevils. Makaza and

Mabhegedhe (2016) found that *S. africana* branches and stems are cut into small pieces used to repel grain weevils (by placing the pieces at the bottom, middle and top of grain storage bags). Other parts harvested and used for repelling grain weevils are twigs and stem bark. A handful of informants (four) indicated that the smoke from burning any part of the tree is used to chase away snakes from households, as well as to repel insects (mostly nuisance mosquitos and flies). Lennox and Bamford (2015) also found that in the olden days, *Vhavenda* used *S. africana* smoke to fumigate their huts against wood-boring and other insects such as mosquitos and flies.

d Crafting and Design

According to Naidoo *et al.* (2012) *S. africana* is utilised in the woodcraft industry. Data collected from the current study confirms that the trunk/stem and thick branches were used in the olden days to design household furniture items such as beds and storage cabinets. Cowhide strips were used as matrasses tied to the bedframe designed from *S. africana* wood. Similar to the building and construction, the wood was preferred for its anti-repellent properties as well as its durability. *S. africana* is poisonous therefore carving of household items that are used to process and/or prepare food for human consumption would be considered unlikely. Interestingly, few informants indicated that *S. africana* can also be used to carve household items such as mortar and pestle, wooden cooking spoon and wooden whiskers. Cywa (2018) also found that *Taxus baccata* which is also considered to be poisonous is used to carve household items such as spoons.

e Firewood

Several informants interviewed in the current study indicated that the smoke of this species is poisonous and has bad smell as a result the wood is not good or preferred as firewood. Lennox and Bamford (2015) also found that nowadays wood from this tree is not usually used as firewood for cooking because the smoke and fumes are poisonous. However, four informants in the current study indicated the smoke and smell produced by this plant whilst burning is tolerable when the material is old and dry compared to when the plant material burnt while still fresh and green. This is because dry material has little or no latex content in them that could result in less smoke and smell being produced when burnt. Dry wood materials from old dead trees are used for firewood particularly for brewing of traditional beer and underground oven for baking. In their study Lennox and Bamford (2015) also found that the tough, soft, light, white wood is used for firewood even though it's toxic. Data from the current study therefore suggest that although *S. africana* is used for firewood, it is not the most preferred species for firewood due to bad smell and poisonous smoke.

f Use in alcoholic beverage

According to Niebler (2017), incense burning is probably one of the oldest methods known to humankind, and new odorants can be formed during the process of burning. Van Wyk and Prinsloo (2019) found that roots, barks, fruits, and seeds of several South African indigenous tree species are harvested and used as beverages. In addition, they also found that fresh or dried leaves that are used in various food dishes add a good aromatic taste to the food and have also become an interest to the fragrance and flavour industry. Interestingly, the current study established that the smoke of *S. africana* is used to musk the smell of a traditional brewed drip alcoholic beverage known to Vhavenda as *thothotho*. This alcoholic beverage is common for its high alcohol concentration and strong smell. An informant interviewed in this study indicated that dry *S. africana* wood, particularly form thin branches, is burnt to produce smoke that will eventually musk the strong smell of Thothotho. This possibly explains why data discussed above indicated that people who brew traditional beer use this species for firewood.

g Infrastructure protection

Trees have been used as windbreaks in the agricultural industry since the 1900. Use of trees as windbreaks involves linear planting of trees and shrubs in such a way that they are strategically integrated into an agricultural landscape so that they simultaneously provide environmental, economic and social benefits (Smith *et al.,* 2021). Akbari (2002) found that trees used as windbreaks reduce the ambient wind speed, which may lower or raise a building's cooling energy use based on its physical structural makeup. Hong and Lin (2014) found that the average velocity of wind decreases significantly around trees. According to He *et al.,* (2014), trees can reduce wind speed thus adjusting microclimate around buildings. The current study has established that in the olden days, *Vhavenda* built their rondavel houses very close to matured *S. africana*. The latter was done to use *S. africana* as a windshield that protected roofs from being blown away by strong winds. *Vhavenda* believed that the round shaped canopy of a matured *S. africana* provides windbreak ability that reduces the wind speed near the houses.

2.3.3 Harvesting methods

Methods and techniques used for collection of plant material required for different uses differs from one part to another. However, cutting (n=45) was found to be the most common harvesting method (Figure 2.13). The intensity of cutting also differ with the part being harvested with a complete cutting down of a tree being the worst. Observations made in filed suggest that harvesters using the cutting method are considerate of future uses. In most cases, only a single stem was found harvested on trees with multiple stems. However, branch harvesting was observed to be the most severe where a tree canopy was completely cut down for harvesting of material thick enough for fencing, toilet stabilization etc. Bark scraping was the second most used method used to harvest stem bark and latex. In this case also only a portion of stem bark was found being harvested as compared to ring barking or bark stripping. As a result, the trees were still able to survive and recover after stem bark harvesting. In most cases, more than one method was recorded from one participant. Users from *Ha-Matsa* village also indicated the harvesting of *S. africana* roots by digging and cutting the root out. However, no evidence of root digging was observed in the study site where *S. africana* population is occurring.

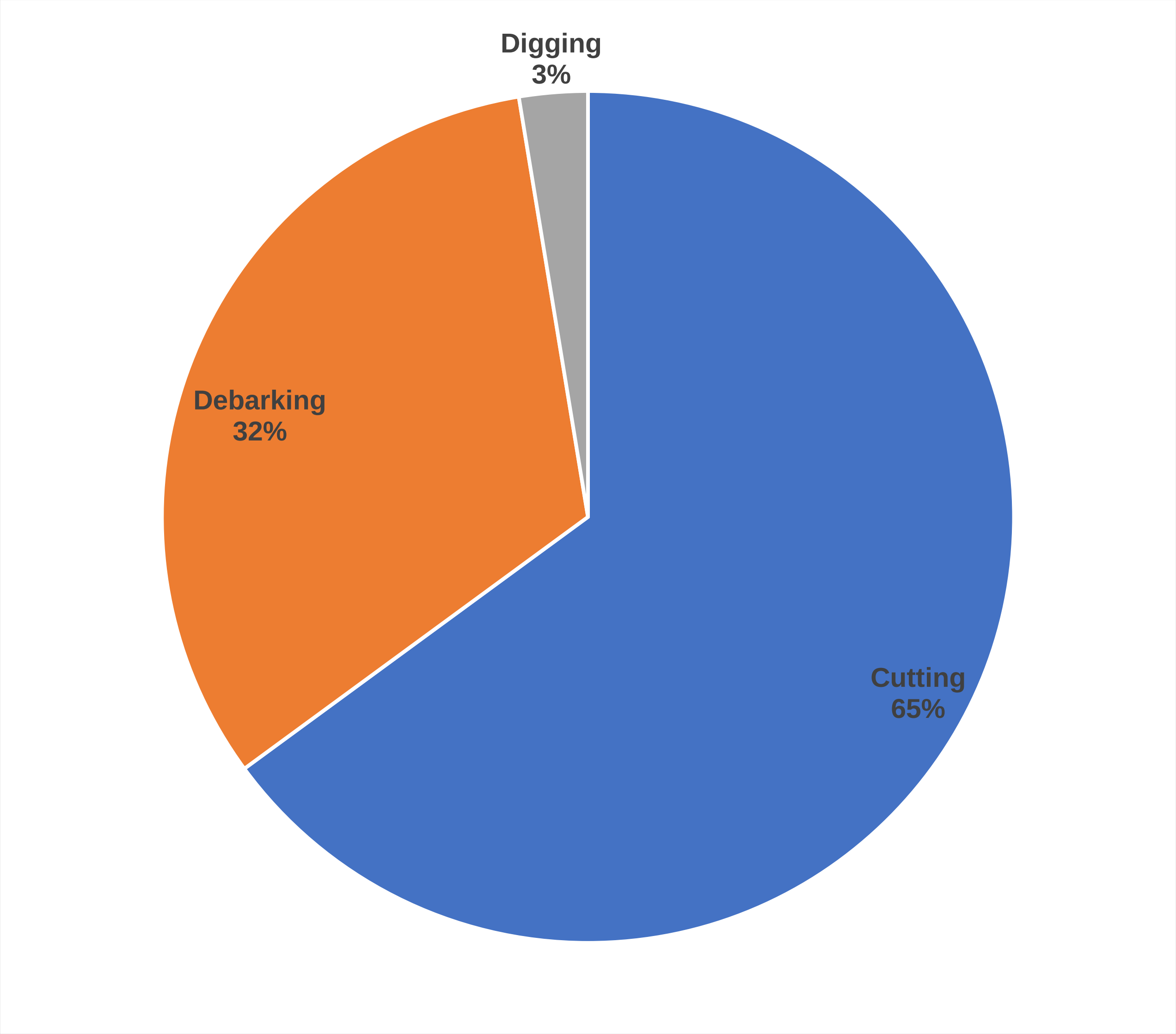

Figure 2.13: Harvesting methods used in collection of *Spirostachys africana* materials.

2.3.4 Perception on availability and protection of *Spirostachys africana* in *Ha-Matsa* Village

Sixty-one percent (n=42) of informants interviewed in this study indicated that *S. africana* is still highly available in the wild (Figure 2.14). Out of these 42 informants 60% (n=25) indicated that similar to *Sclerocarya birrea* and *Adansonia digitata* the species under investigation is very important to *Vhavenda* people and should be protected. Twenty (20) of the 26 informants that indicated that the species is moderately available in the wild highlighted the need to protect *S. africana.* Furthermore, there was only 1 informant indicated that *S. africana* is no longer found in the wild at *Ha-Matsa* village. This informant also indicated that if this species still occurs elsewhere, it must be protected. Only 23 informants interviewed in this study indicated that there is no need to protect *S. africana*.

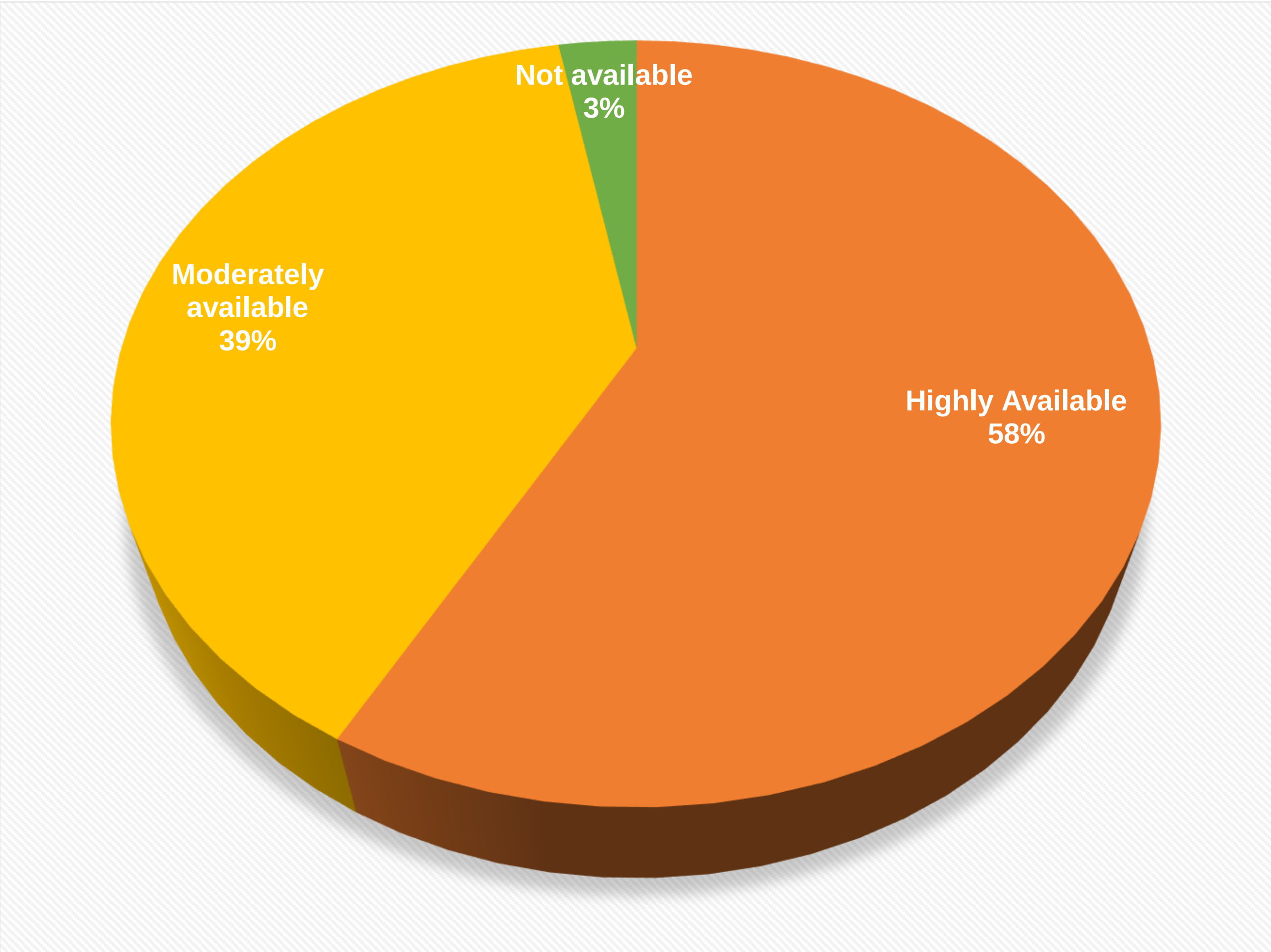

Figure 2.14: Informants' perceptions on the availability of *Spirostachys africana*.

Overall, 67% (n=46) participants suggested that *S. africana* must be protected versus 33% (n=23) that suggested that the species requires no formal protection (Figure 2.15). Most reasons provided by those who suggest that the species does not need protection included that the species is no longer used as much as it was used to in the olden days.

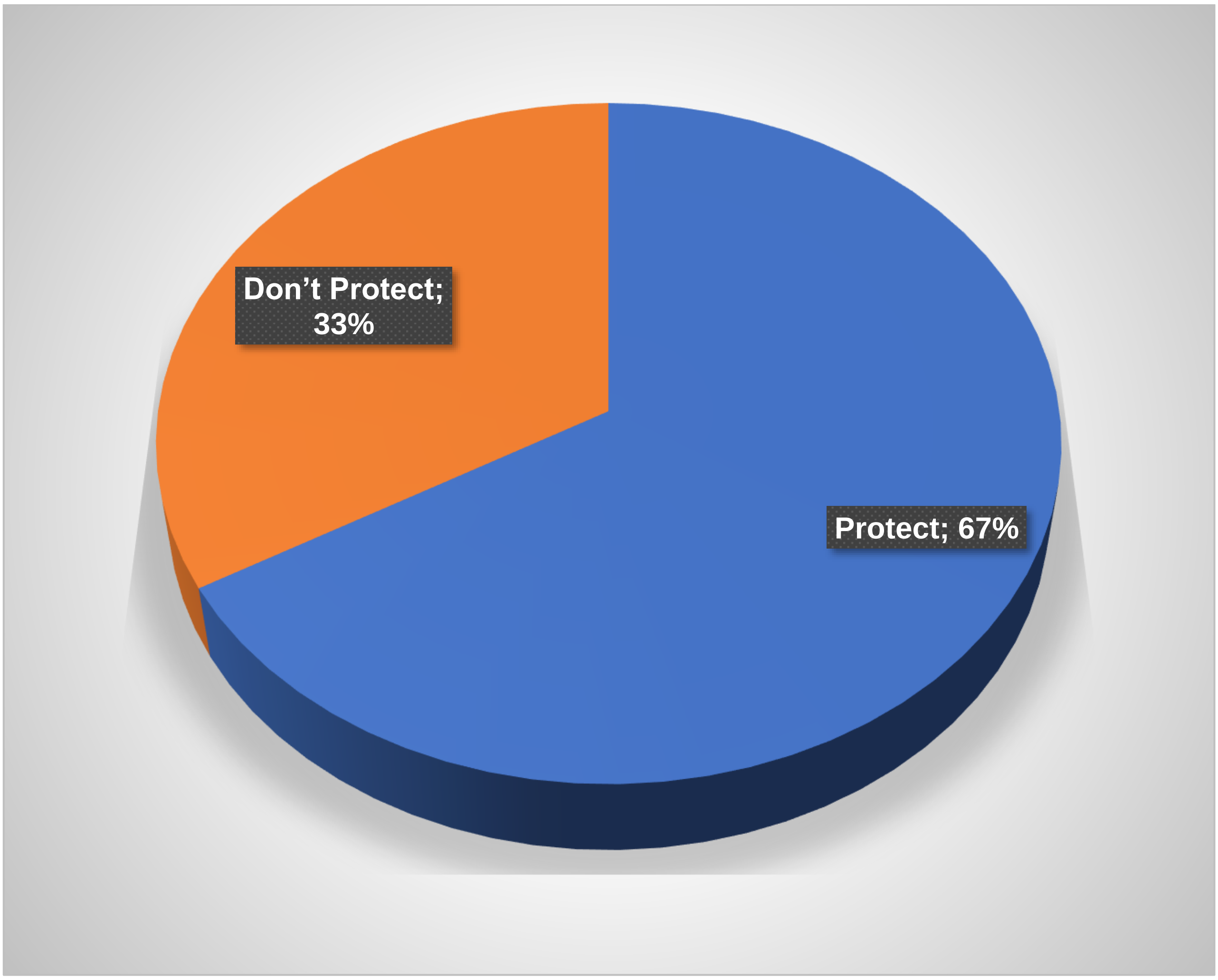

Figure 2.15: Informants perception on the need to protect *Spirostachys africana*.

2.4 Conclusion

A study on ethnobotanical utilization of *S. africana* at *Ha-Matsa* village revealed that residents of this area harvest and use this species. Data collected shows that various parts of *S. africana* mainly branches, stem bark and stem are harvested for various uses ranging from medicinal use, building and construction, pesticide/anti-repellent, crafting, firewood and infrastructure protection. Use of *S. africana* for traditional medicine purposes was found to be the most common among different age groups and sex with adult and elderly female contributing more information on medicinal use. Data further revealed that *S. africana* is also popular in the *Ha-Matsa* village for its hardwood that has anti-repellent properties that is used mostly for building and construction particularly for fencing and stabilization of pit toilets. The study also identified lack of interest on indigenous knowledge by youth as noted in several studies (Vitalini *et al*., 2013; Corrigan *et al*. 2011; Chepkosgei and Jerotich, 2016; Amjad *et al*., 2020; Wanjohi *et al*., 2020). The data collected also showed that there is no harvesting strategy or plan for *S. africana* in this area as a result harvesting occurs as and when required. This raises a concern as species may be harvested in the wrong season or at the wrong growth stage.

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Chapter 3

THE POPULATION ECOLOGY OF *Spirostachys africana* SOND. AT *HA-MATSA* VILLAGE, LIMPOPO PROVINCE, SOUTH AFRICA

3.1 Introduction

Tree species are a source of multiple benefits to the savannah through maintenance of ecosystem by provision of breeding sites for fauna and acting as a safety net against poverty of communities by delivering goods and services in the form of fuelwood, timber, and medicinal products (Madonsela *et al.,* 2018). The influences of human on natural resources particularly tree species are however problematic for the species conservation, and they mostly affect functioning of the ecosystems and the benefits they provide (Jima and Megersa, 2018) due to over-exploitation and unsustainable use of use of biodiversity and its components (Deepa, *et al.,* 2018). Over-exploitation, unsustainable use of natural resources, increasing agricultural expansion, fire, construction, overgrazing, and urbanization mostly result in most of slow growing trees e.g. *S. africana* dying and fail to recover leading them to becoming either rare or endangered over time (Tshisikhawe, 2012; Jima and Megersa, 2018).

Harvesting as in many other anthropogenic disturbances plays a major role in shaping population structure of plant species (Bakali *et al.,* 2017). Effects of harvesting usually depend on factors such as the plant part harvested, life history of the species, season of harvesting as well as the intensity of harvesting (Schmidt and Ticktin, 2012; Soumya *et al.,* 2019). Understanding the effects brought about by various types of disturbances on plants is important in designing multiple-use management plans for semi-arid savanna systems (Van Coller *et al.,* 2018). Lack of management practices can for an example lead to early or inappropriate harvesting of tree species (Schmidt and Ticktin, 2012). Harvesting regime (i.e. season, intensity, and interval) has effect on the population dynamics of species being harvested (Schmidt and Ticktin, 2012). Early harvesting for an example eliminates sexual reproduction and causes adult mortality. Assessing the effects of harvesting on the population of tree species is therefore important in informing species conservation options, guided sustainable harvesting practices and offtakes, as well as supporting local livelihoods (Soumya *et al.,* 2019). According to Ticktin *et al.* (2018), studies considering the ecological impacts of harvesting need to take a more community or systems view that mirrors the multiple positive and negative links between the plant species of interest and other species and processes that may be occurring simultaneously with harvesting.

Understanding the population dynamics (population ecology) of species particularly in communal areas and areas that are easily accessible to the public is important because unsustainable harvesting of plants can drive a vegetation into patchiness or narrow distribution of plant species (Botha *et al.,* 2017). This assists in paving way for the development of sustainable harvesting strategies as well as development of conservation options of various species (Soumya *et al.,* 2019). Population ecology studies study population size structure and geographical distribution of species, as well as how and why these changes or stay constant over time (*Cousins et al.,* 2014). These studies provide an understanding of impact of the interactions between species and their environment (environmental conditions, resources, neighbours, and disturbance) and they are important baseline information for monitoring and conservation of species (Tshisikhawe *et al.,* 2012; Cousins *et al.,* 2014).

Knowledge of species population size structure, information on the distributions of its abundance in both time and space helps in explaining the relationships between the species and its environment (Cousins *et al.,* 2014). Population size structure can be assessed by an analysis of frequency distribution of stems across diameter size-classes. Knowledge on the lifeform variables of a population can be used in a more refined analyses of its population (Tshisikhawe and Van Rooyen, 2013). The use of a size-class distribution analysis provides a practical field method for the investigation of population structure and at the same time illustrate the response of the population to harvesting pressures (Tshisikhawe *et al.,* 2012). Tree size-class distributions can also provide demographic information on regeneration and recovery from disturbances (Muvengwi *et al.,* 2020). Abundant seedlings and juvenile individuals relative to adults in a population is generally interpreted as an indication of a healthy, stable, and potentially growing population. Conversely, a scarcity of seedlings and juveniles may indicate a declining population (Cousins *et al.,* 2014). At a plant community level, species richness is considered a size-class dependent phenomenon (Tshisikhawe, 2012).

Variations in population size structure and density within a species distribution may be brought about as a result from numerous factors, such as differences in disturbance severity, habitat degradation or fragmentation, and the extent of available habitats. The size and density of individual populations on the other hand may also vary from one year to another based on spatial and temporal patterns in rainfall and disturbances (Cousins *et al.,* 2014).

3.2 Study area, materials, and methods

3.2.1 Study Area

This study was carried out at *Ha-Matsa* village located in Makhado local municipality, within the Vhembe district in province of Limpopo, South Africa (Figure 3.1). The village is found within a savannah biome with predominantly a mix of Lowveld and Bushveld vegetation types. The area is represented by semiarid climatic zone with dry, cold winters and hot, wet summers and experiences periodic droughts.

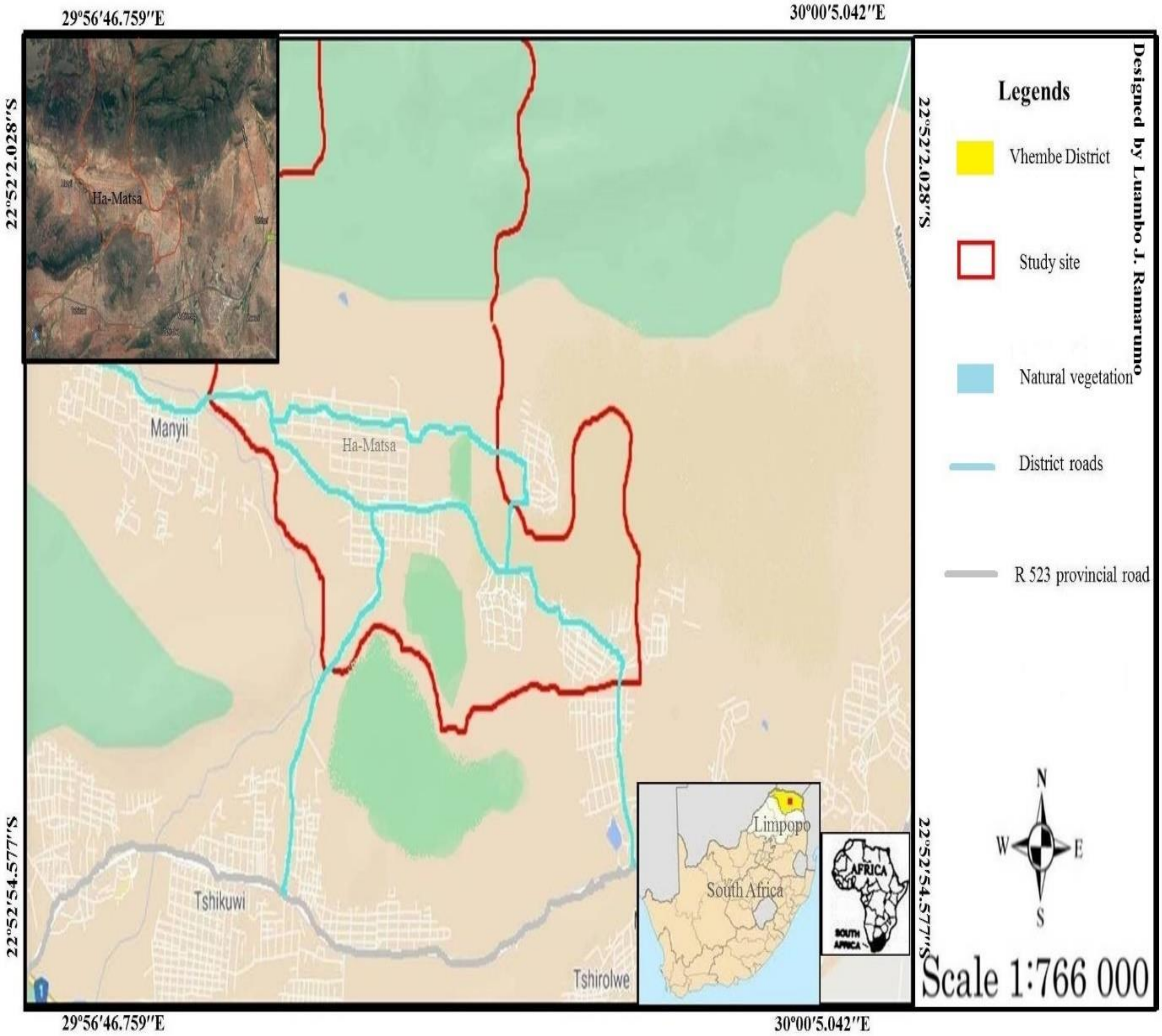

Figure 3.1: A map of *Ha-Matsa* village study area.

3.2.2 Methodology

Eleven 100m X 10m line transect were subjectively laid in the population of *S. africana* using tape measures. Transect was constructed by laying down tape measure on a straight line in the middle of the transect. *S. africana* individuals within five meters on the either side of the tape measure for each transect, were sampled and the following data was recorded:

a) height using a height measuring pole,

b) basal stem diameter with a diameter tape, and

c) Crown health status using zero (0) to five (5) sliding scale estimate (Tshisikhawe *et al.,* 2012) as follows:

0 – 100% mortality

1 – Severe crown damage,

2 – Moderate crown damage

3 – Light crown damage,

4 – Traces of crown damage,

5 – Healthy crown.

Each *S. africana* individual was also assessed for evidence of harvesting, and part or section of the tree were harvesting evidence was observed was recorded. Photographs of sample site were taken before, during and after sampling using digital camera. Form of disturbance either anthropogenic or natural other than harvesting observed in the study site were recorded. Data collected was captured and analysed for frequencies through descriptive statistical analysis of Microsoft Office Excel programme.

3.3 Results and discussion

3.3.1 Population structure of *Spirostachys africana*

Basal stem diameter (BSD) is useful as a measure of tree size since it doesn't usually gets modified by damage from natural disturbance such as herbivory or fire (Helm and Witkowski, 2012). *S. africana* individuals found in this study were grouped into four age classes namely: seedlings (individuals with BSD of 0.1cm to 1cm), juveniles/young (individuals with BSD of 1.1cm to 20cm), sub-adults (individuals with BSD of 20.1cm to 60cm) and adults/matured (individuals with BSD of 60.1cm or more). Table 1.1 shows that 96 *S. africana* individuals were found in the study area with most individuals recorded under the sub-adults (n=60) category. A total of 23 young and 13 adult/matured individuals were recorded. No seedlings were found in this study, however two individuals resprouting from the stumps that were cut very close to the ground (about 10cm from the ground) were observed and this were recorded under the young age class as per stem diameter.

Table 1.1: Age class categories and frequency of recorded *S. africana* individuals.

Age Class	Total # of individuals
Seedlings	0
Young	23
Sub-Adults	60
Adult/Matured	13
Total	96

To determine the size-class distribution curve of *S. africana* population, individuals were further grouped into five categories based on their basal stem diameter. There are three ideal types of size-class distribution curves that can be recognized for tree populations; namely, the typical reverse J-shaped curve, the bell-shaped curve, and the straight horizontal line (Tshisikhawe and Van Rooyen, 2013). Traditionally, inverse J-shaped curve is an indicative of healthy and stable plant populations represented by continuous recruitment of seedlings (Tshisikhawe and Van Rooyen, 2013; Cousins *et al.,* 2014). The bell-shaped curve is an indicative of lack of seedlings and young plants, and it is mostly represented by high number of sub-adult individuals. The straight horizontal line depicts a population with relatively low establishment of seedlings and young plants (Tshisikhawe and Van Rooyen, 2013). Tshisikhawe et al. (2012) ascertained that a population that fails to recruit new seedlings has high probability of facing local extinction. Figure 3.2 shows a bell-shaped size-class distribution curve of *S. africana* population at *Ha-Matsa* village. This means that the *S. africana* at *Ha-Matsa* Village is failing to recruit seedlings and has proportionally few young individuals. Cousins *et al.* (2014) observed a bell-shape size-class distribution curve when they studied the population structure of *Aloe plicatilis.* They ascribed their results to low inter-annual variation in rainfall, possible theft and herbivory of individuals in the smaller size-classes that could be resulting in episodic or no recruitment of seedlings. In the current study, lack of recruitment of seedlings can be ascribed to harvesting regime that were observed and the fact that the study area is located in a communal land with evidence of ruins and various anthropogenic activities such as fires.

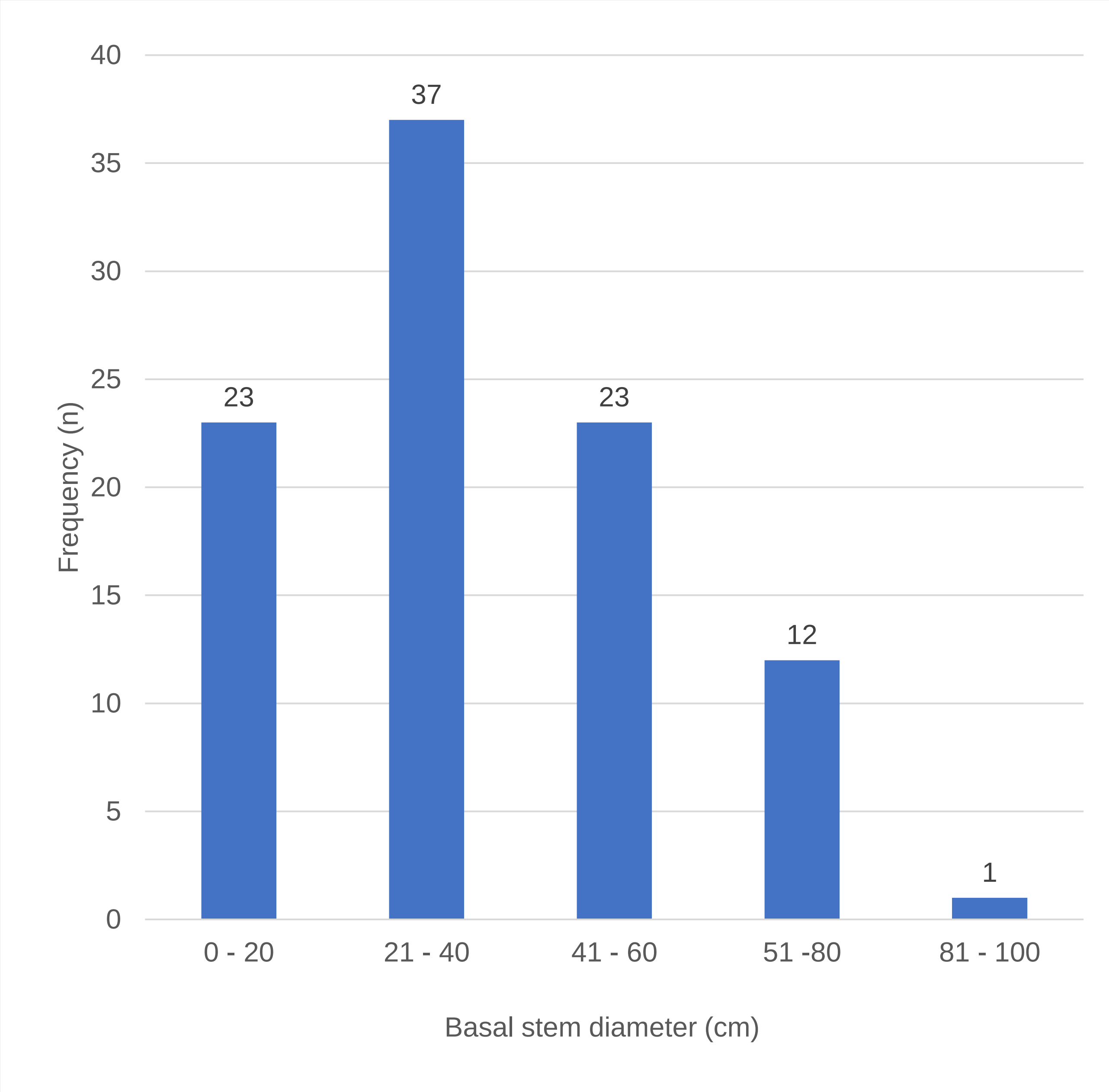

Figure 3.2: Basal stem diameter size-class distribution of *Spirostachys africana* population sampled at *Ha-Matsa* village.

3.3.2 Plant heights assessments

The plant heights were categorised into five class sizes and percentage representation for each category was also calculated (Figure 3.3). According to Lennox (2019), an adult/mature *S. africana* can grow to a height of between 10-18m tall. Fifty percent of individuals recorded in the current study were found to occur in the middle height category

(4.1 - 6m), followed by 33% of individuals that are between 6.1m and 8m tall. Low number of small trees of height between 0 and 4m (13%) as well as trees taller than 8m (9%) was recorded. Only 3% of *S. africana* trees (n=3) recorded in this study were found to have reached about 9.5m tall. This means that only 3% of the surveyed population managed to reach their maximum height and most likely maturity stage. Observations made in the current study clearly indicate that harvesting regimes have impacted height of *S. africana* species. The impact of branch harvesting possibly explain the lack of seedlings in the study area. Bakali et al. (2017) studied the population structure of *Androstachys johnsonii* and recorded low percentage (about 80%) of individuals that reached their maximum growth height similar to the current study. They associated repeated harvesting of *A. johnsonii* as a reason for majority of individuals not reaching maximum height. The plant height measurement data further confirms that the *S. africana* population of *Ha-Matsa* is not recruiting new seedling that will mature into seed producing adults as a result this population is unstable.

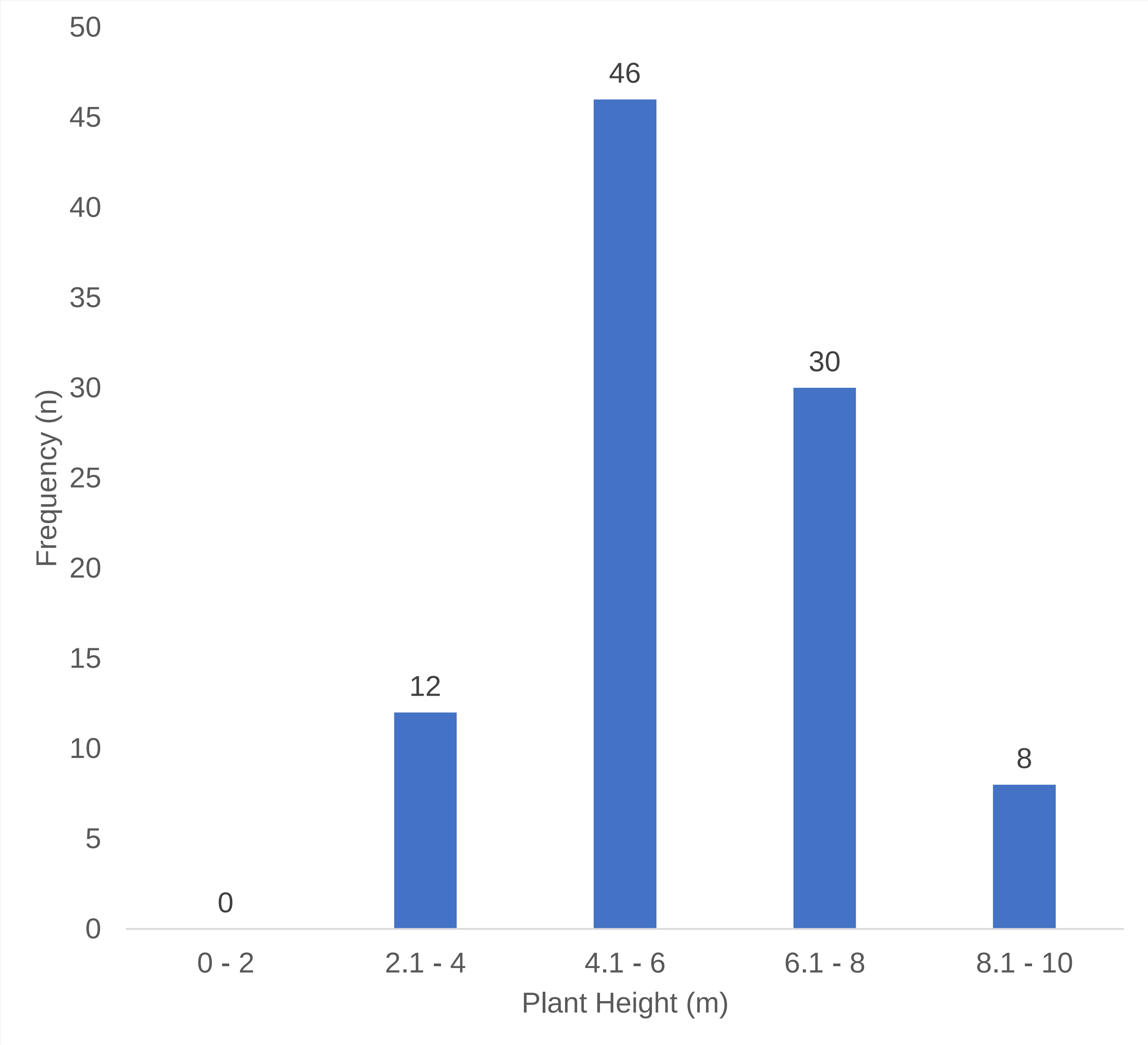

Figure 3.3: Height class distribution of *Spirostachys africana* population sampled at *Ha-Matsa* village.

3.3.3 Harvesting impact on *Spirostachys africana*

The most direct impact that harvesting has is on the survival, growth, and reproduction, of the harvested individual (Ticktin and Shackleton, 2011). Sixty percent (60%) (n=58) of *S. africana* plants surveyed were found to have evidence of harvesting. No evidence of harvesting was found in the remainder 38 (40%) *S. africana* trees. Harvesting of *S. africana* found in this study varied from stem bark harvesting (Figure 3.4), harvesting of branches/canopy section (Figure 3.5), to a complete chopping down of a whole tree (Figures

3.6). Cutting by panga, axe and/or saw was observed and found to be the most preferred method used to harvest required parts of the tree. The results further show that large number of adult/matured (i.e. individuals with basal stem diameter of greater than 20cm) *S. africana* trees (n=53) were harvested. Evidence of harvesting of multiple parts of *S. africana* in the adult/matured age class were also observed in twenty-three (23) individuals, this excludes a total of three trees that were completely cut down with only stumps left.

Figure 3.4: Evidence of stem bark harvesting observed on *Spirostachys africana* stem at *Ha-Matsa* village (Photo: M.V. Phalanndwa, 2021).

Figure 3.5: Evidence of crown harvesting observed on *Spirostachys africana* at *Ha-Matsa* village (Photo: K Magwede, 2020).

Figure 3.6: Remaining stump of *Spirostachys africana* observed at *Ha-Matsa* village (Photo: M.V. Phalanndwa, 2021).

a Stem harvesting

The current study found evidence of stem harvesting on 11% of *S. africana* trees surveyed. Interestingly, harvesting of stems were predominately found on *S. africana* trees that had multiple stems. Apart from the three (3) adults/matured trees that were completely chopped down with only stump left, only a single stem from those trees with more than one stem was cut. This could suggest that individuals harvesting *S. africana* stems have some level of understanding of a need to harvest the species in a sustainable manner. Evidence of resprouting were observed at the base of all *S. africana* stumps that were assessed (Figure 3.7). Bakali, *et al.,* (2017) also found similar form of resprouting of *Androstachys johnsonii* at the base of stumps after harvesting. This pattern of resprouting was associated the height at which the tree was cut and is understood to have an impact on sources of buds for resprouting.

Figure 3.7: *Spirostachys africana* resprouting from a stump that remained after stump harvesting (Photo: M.V. Phalanndwa 2021).

b Bark Harvesting

According to Delvaux *et al.,* (2009), harvesting bark or roots can be more damaging in terms of tree survival. However, in their study they found that tree response to bark harvesting regimes is species-specific. Tshisikhawe *et al.,* (2012) found that *S. africana* bark is harvested for medicinal purposes. In the current study, evidence of stem bark harvesting was observed on 39% (n=27) of trees surveyed. Seventy percent of trees with evidence of stem bark harvesting were sub-adults, followed by adults/matured with 22% and only 8% of adults/matured trees. Majority of trees were lightly damaged with only one individual showing evidence of bark stripping (Figure 3.8). Stem bark harvesting observed in the current study seemed to have no significant impact on the health and survival of *S. africana* trees surveyed.

Figure 3.8: An individual with severe stem bark harvesting as observed at *Ha-Matsa* village (Photo: M.V. Phalanndwa, 2021).

An old scar of root bark harvesting was also observed on the exposed root of one (1) *S. africana* individual (Figure 3.9). Interestingly, the same root that had bark harvesting scar was found to be recovering and it had evidence of root suckering. It is important to note that none of the literature reviewed had indicated that *S. africana* can grow through root suckering which makes this study the first to establish root suckering in this species.

Figure 3.9: Harvesting scar on exposed root of *Spirostachys africana* observed at the study site (Photo: M.V. Phalanndwa, 2021).

c Crown health

Changes in canopy density influences not only light regime but other microclimatic changes such as air and soil temperature or humidity may also occur (Wagner *et al.*, 2011) and may in turn influence species diversity and abundance. The condition of tree crowns is therefore an important indicator of tree health (Morin *et al*., 2015). The crown health data (Figure 3.10) showed that *S. africana* population of *Ha-Matsa* is dominated by trees with some level of crown damage. Twenty four percent of the trees were found to have moderately damaged crown, followed by 20% of trees with severely damaged crown, 15% with lightly damaged crown, 14% with traces of crown damage, and 9% of trees that had complete mortality of crown, or the crown was completely removed. Nineteen percent of the trees displayed signs of healthy crowns however, some of these trees with healthy crown had other parts harvested particularly the stem bark. Thus, high number of *S. africana* found in this study had evidence of crown harvesting or disturbance. Anthropogenic activities such as fires observed in this study, as well as severe weather conditions could be driving plants in this area into distress. Morin *et al.,* (2015) ascertained that crown dieback is the most important crown condition variable for predicting tree species survival. Impact of crown harvesting observed in the current study therefore suggest that majority of *S. africana* trees at *Ha-Matsa* village are unhealthy and this can also be associated with the decrease in rate of growth and seed production, which potentially explains why no seedlings were observed in this study.

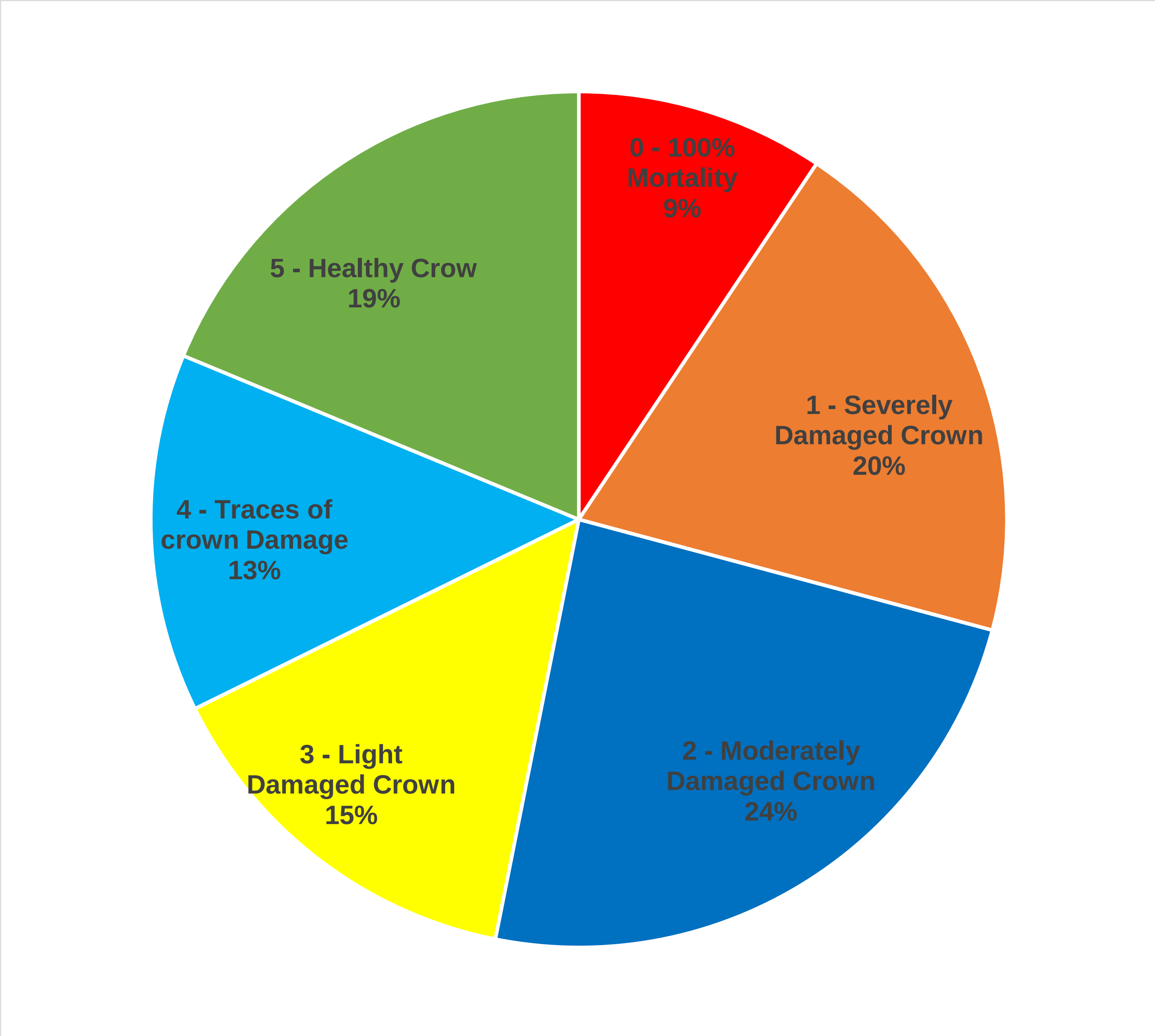

Figure 3.10: Crown health status of *Spirostachys africana*.

3.4 Conclusion

Severe harvesting particularly wood harvesting lowers woody species structural variables i.e. height, stem basal area and canopy cover (Muvengwi *et al*., 2020) resulting in a greater probability of reducing seed availability as a result leading to a decreased or no regeneration of a population. Stressed plants tend to reduce their rate of growth and subsequently seed production. Data collected from this study clearly indicates that *S. africana* is harvested for different uses and multiple parts/organs of this tree are being utilised with the canopy or crown of this species being severely impacted. The BSD data and tree height data indicate the *S. africana* population of *Ha-Matsa* village is predominately represented by sub-adults and fewer adult/matured trees, as well as few young trees. And due to the severity of harvesting particularly in the crown and stem sections majority of trees surveyed were found to have unhealthy crown. The latter together with extreme weather conditions, anthropogenic activities observed in the study area resulted in lack of seedlings.

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Chapter 4

GENERAL SUMMARY, CONCLUSION AND RECOMMENDATIONS

4.1 Summary

This study was conducted at *Ha-Matsa* village; this village is predominately comprised of *Vhavenda*. *Vhavenda* use indigenous plants for food, medicine, firewood, building, art, as sources of oils and dyes, for shade and as ornamentals (Mabogo 1990). The study investigated ethno-ecology of *S. africana* Sond. species focusing on the population found at *Ha-Matsa* village. This study was divided into two (2) sections namely: ethnobotanical use of *S. africana* and the population structure of this species. The ethnobotanical use study was conducted using a semi-structured questionnaire following the identification of informants using a convenient non-probability random sampling technique. Informants interviewed for this study were mostly adult and elderly female and a handful of male and youth. Various information such as uses, parts used, harvesting techniques, and availability perception etc. of *S. africana* were recorded to establish if this species is being utilised. A total of 69 informants (53 female and 16 male) were interviewed, and a total of seven (7) categories (Medicinal, building and construction, pesticide/anti-repellent, crafting & design, food & beverages, firewood, and infrastructure protection) of *S. africana* uses were recorded. Majority of informants indicated that the species is used mostly for traditional medicine and construction.

An investigation on the population structure of *S. africana* was triggered by intensive harvesting of this species that was observed in the communal land at *Ha-Matsa* village. This was achieved through the construction of transect in the area where *S. africana* was found. The transects were subjectively placed to ensure that all transects included *S. africana*. Eleven 100m x 10m transects were established; number of individuals within each transect were counted and for each individual basal stem diameter (BSD) and plant height were measured. Crown health and evidence of harvesting on any organ/part of *S. africana* were also recorded. Ninety-one *S. africana* individuals were recorded in this study and the basal stem diameter as well as plant height data showed that the population studied is predominantly represented by individuals in the sub-adult age class with very few young and adult individuals. In addition, no seedlings were found in this study. This data coupled with the impact of harvesting, particularly harvesting of the branches suggest that the *S. africana* population at *Ha-Matsa* village is unstable and it could be under threat.

4.2 Conclusion

Drawing from the ethnobotanical use data collected and discussed in this study, the *Vhavenda* of *Ha-Matsa* village rely on *S. africana*. Utilization of this species varies from traditional medicine, building and construction, to pest control etc. The harvesting technique data collected suggests that cutting by panga, axe, saw etc. is the most used method to harvest *S. africana* with collected material varying from a small piece wood/twig to a whole tree. Furthermore, *S. africana* in this area is harvested and utilised on an as and when required basis, which could be problematic if the harvesting occurs at the wrong time concerning the season of harvesting and age of the individuals that are harvested.

Sixty percent (60%) (n=58) of *S. africana* plants surveyed were found to have evidence of harvesting. This confirms the ethnobotanical use data that suggests that the *Vhavenda* of *Ha-Matsa* utilise *S. africana*. Evidence of cutting were observed in the majority of trees surveyed, further confirming cutting as the most preferred harvesting technique used by *Vhavenda* of *Ha-Matsa* village as suggested by the ethnobotanical use data. Crown health data ascertained that 81% of the trees surveyed had crown damage and this is understood to be the reason why the *S. africana* population at *Ha-Matsa* is failing to recruit seedlings.

This study therefore concludes that *Vhavenda* of *Ha-Matsa* village are utilizing *S. africana* for various purposes. Furthermore, the population of *S. africana* at *Ha-Matsa* Village is failing to recruit seedlings with only few young and sub-adult trees able to survive into maturity stage. Therefore, the population of *S. africana* at *Ha-Matsa* village was found to be unstable.

4.3 Recommendations

Result from the current study revealed that *Vhavenda* of *Ha-Matsa* village harvest and *S. africana* for various purposes. Ethnobotanical data has showed that the species is mostly used for traditional medicine, fencing and stabilization of pit-toilets. Similar to other indigenous knowledge-based studies, date from this study further revealed that youth have no interest in preserving indigenous knowledge. It was further established that harvesting of *S. africana* happens as and when required (irrespective the season, age class of individuals and organs being harvested) without any form of harvesting strategy in place. Majority of the informants interviewed indicated that stem bark and branches are the most preferred organs of *S. africana* that are mostly harvested and used. The population structure data (ecological data) also established that stem bark and branches of *S. africana* are being harvested. However, bark harvesting was found to have no significant impact on the health of *S. africana* individuals in the study area. This was ascribed to the fact that 100% of individuals that were found to have stem or root bark harvesting scars were found to be recovering but at a very slow rate more especially in adult/matured trees. Harvesting regime/pattern of branches/canopy/crown section of *S. africana* individuals on the other hand was found to have huge impact on the health of individuals harvested. The latter was understood to be that reason why the *S. africana* population at *Ha-Matsa* Village is failing to recruit seedlings. As indicated under the study area section of this study, the *Vhavenda* of *Ha-Matsa* village still rely heavily on natural resources for ecosystem service delivery. This means that harvesting of *S. africana* and other species for traditional medicine, building, etc.

is likely to continue. The harvesting regime/pattern observed in the current study particularly harvesting of branches/canopy/crown section raises a concern on the population status of this species. According to the IUCN, *S. africana* is listed as a species of least concern but if harvesting patterns observed in the current study are occurring elsewhere, the species could potentially be facing local extinction.

It is therefore recommended that similar studies focusing on the uses and impact of harvesting on various savanna species particularly species that are in communal land be conducted. An in-depth distribution and population study i.e. long-term population monitoring of *S. africana* be conducted. According to Moussy *et al.* (2021), long-term population monitoring studies provide a substantial depth of knowledge about plant population dynamics and their implications for conservation and management. These studies can therefore provide insight on whether the conservation status of *S. africana* be revised. It is further recommended that more and more indigenous knowledge-based studies particularly in the Venda region be conducted before this form of knowledge is lost forever.

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APPENDIX

Appendix A: Ethnobotanical survey questionnaire

Personal Details of informant

Gender: Male ☐ Female ☐

Age: Youth ☐ Adults ☐ Elders ☐

Educational background: Never attended school ☐

Attended Primary Education ☐

Attended Secondary Education ☐

Attended Tertiary ☐

Species information

What is the name/s of this plant? ____

How do you distinguish it from other trees? ____________________________________

Do you know any other area besides here where this tree is found? Yes/No, if yes where else is it found? ____

What are the uses of this species if any? ______________________________________

What part/s of the tree are used? ____

How did you extract/harvest the part of the tree? ________________________________

How is it prepared for use? ____

How many times is it applied/used? ____

Is it mixed with any other species when used? Yes/No, if yes which tree?

____

Is there a preferred season for harvesting? Yes/No, if yes, what is the preferred season? ___

How available is the species in this area?

Highly available ☐ Moderately available ☐ Not available ☐

Do you think this tree is important and need protection?

____

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