Threatened plant species in Vhembe Biosphere Reserve, Limpopo province, South Africa: Problems and prospects of conservation and utilization

By

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Submitted in partial fulfillment of the requirements for the degree

Of

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Date: 22 March 2022

Declaration

I, **Luambo Jeffrey Ramarumo** (201816821) declare that this thesis submitted to the University of Fort Hare for the degree Doctor of Philosophy in Ethnobotany in the Faculty of Science and Agriculture, is my own original work and has not been submitted for any degree at this institution or elsewhere. This thesis does not contain any materials written by other scholars except where otherwise mentioned and referenced accordingly.

I also declare that I am fully aware of the University of Fort Hare policy on plagiarism and I have taken precautionary measures to comply with the University regulations.

Finally, I declare that I am fully aware of the University of Fort Hare policy on research ethics and I was permitted to conduct my research.

Signature:________________________Date: 22 March 2022

Luambo J. Ramarumo (Doctoral Student Researcher)

As a student's supervisor, I have agreed to the submission of this thesis

Signature:________________________Date: ____________________________2022

Prof. A. Maroyi (Supervisor)

Declaration for publications

Some of the information presented in this thesis have been published or sent for publication purpose in various peer-review DHET accredited journals.

The published research articles included the following:

1. **Ramarumo, L.J.** and Maroyi, A., 2020. An inventory of useful threatened plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa. *Biodiversitas Journal of Biological Diversity*, ***21***(5): 2146–2158.
2. **Ramarumo, L.J.,** Maroyi, A. and Tshisikhawe, M.P., 2020. Plant species used for birdlime-making in South Africa. *Bangladesh Journal of Botany:* ***49***(1): 117–124.
3. **Ramarumo, L.J.,** Maroyi, A. and Tshisikhawe, M.P., 2019. *Asparagus sekukuniensis* (Oberm.) Fellingham & N.L.Mey.: A threatened medicinal plant species used by Vhavenḓa in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa. *Journal of Applied Pharmaceutical Science*, ***9***(06): 080–085.
4. **Ramarumo, L.J.,** Maroyi, A. and Tshisikhawe, M.P., 2019. *Bowiea volubilis* Harv. ex Hook. f. subsp. *volubilis*: A therapeutic plant species used by the traditional healers in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa. *Journal of Pharmaceutical Sciences and Research*, ***11***(7): 2538–2542.
5. **Ramarumo, L.J.,** Maroyi, A. and Tshisikhawe, M.P., 2019. *Warburgia salutaris* (G. Bertol.) Chiov.: An Endangered Therapeutic plant used by the Vhavenḓa ethnic group in the Soutpansberg, Vhembe Biosphere Reserve, Limpopo province, South Africa. *Research Journal of Pharmacy and Technology*, ***12***(12): 5893–5898.
6. **Ramarumo, L.J**., Maroyi, A. and Tshisikhawe, M.P., 2019. *Euphorbia pulvinata* Marloth: A useful succulent plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa. *Indian Journal of Traditional Knowledge*, ***18***(1): 122–126.

Research article under review

1. **Ramarumo, L.J.** and Maroyi, A., 2021. A review of threatened plant species utilization, conservation status and distribution in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. *Pakistan Journal of Botany.*

Manuscript under preparation

1. **Ramarumo, L.J.** and Maroyi, A., 2021. Indigenous conservation in the Vhembe Biosphere Reserve, Limpopo province, South Africa. Targeted journal: *Indian Journal of Traditional Knowledge*.
2. **Ramarumo, L.J.** and Maroyi, A., 2021. The processing of plants derived roof waterproofing in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. Targeted journal: *Sustainability*.

Dedication

This piece of work is dedicated to my lovely wife (Livhuwani Mabada-Ramarumo) and my kids (Unarine, Roana, Zwivhuya and Roanda Ramarumo) who guaranteed me with unconditional love and support throughout my doctoral journey. To my kids (Unarine, Roana, Zwivhuya and Roanda Ramarumo), I would like to see them deciding their own.

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Abbreviations

CBD - Convention on Biological Diversity

CITES - Trade in Endangered Species of Wild Fauna and Flora

CR - Critically Endangered

DHET – Department of Higher Education and Training

EN – Endangered

FL - Fidelity Level

GPS - Global Positioning System

IPNI - The International Plant Names Index

IUCN - International Union for Conservation of Nature

LEDER - Limpopo Provincial Department of Economic Development, Environment and Tourism

MAB - Man and Biosphere Program

NDP- National Development Plan

NEMBA - National Environmental Management, Biodiversity Act

PRA - Participatory Rural Appraisal

RFC - Relative Frequency of Citations

RRA - Rapid Rural Appraisal

SANBI - South African National Biodiversity Institute

TOPS - Threatened or Protected Species

UN - United Nations

UNESCO - United Nation Educational, Scientific and Cultural Organization

UV - Use Value

VU – Vulnerable

WNBR - World Network of Biosphere Reserves

Abstract

Threatened plant species are those species that are vulnerable or at the risk of extinction. According to Version 3.1 of the International Union for Conservation of Nature (IUCN)'s Red List Categories and Criteria, the three categories of threat in order of increasing risk of extinction are: Vulnerable (VU), Endangered (EN) and Critically Endangered (CR). These species are oftenly protected by both national and international obligations. Scientific evidence suggests that threatened plants are disappearing at an alarming rate. The current expansion of agricultural land, urbanization, over-exploitation of biological resources, climate change and invasive alien species are regarded as major drivers of biodiversity loss and high rate of species extinction worldwide. Scientists and conservation managers are seeking to understand and monitor plant species that are likely to be on the verge of extinction. Monitoring of threatened plants can be better achieved through insights about indigenous knowledge dynamics associated with such species. Scientific scholars including botanists, ethnobotanists, conservationists and anthropologists, all share common interest about the use of indigenous knowledge for livelihoods, scientific and economic growth. As a result, there is a growing interest on indigenous knowledge researches, particularly involving utilization and conservation of plant species. Given the fact that recent scientific evidence suggests that such studies are lacking in South African Biosphere Reserves, as well as the fact that scientist and conservation managers are seeking to understand species likely to be on the verge of extinction risk. It is within this context that this study is aimed at investigating threatened plant species utilization, conservation statuses and distribution in the Vhembe Biosphere Reserve, Limpopo Province in South Africa. The hypothesis of this study states that traditional knowledge about utilization, distribution and conservation statuses of threatened plant species provide suggestions for appropriate conservation practices.

Since the current study is ethnobotanical in nature that is focusing on human interactions with plants, the research methods used addressed multidisciplinary aspects and involved disciplinary integration. An integrated participatory research approach focusing on shared learning, forging collaborative relations with participants, analyzing and validating the shared knowledge was used to document ethnobotanical data within the study area. This research approach was selected as it is considered to be a quick and effective way of acquiring data associated with indigenous knowledge systems. To offset the elements of bias during data collection, the research technique was designed to accommodate core principles that

interlinked participatory rural appraisal (PRA) and rapid rural appraisal (RRA). Furthermore, the integrated core principles of participatory rural appraisal and rapid rural appraisal were used with conventional methods such as field surveys and interviews using questionnaires. Therefore, ethnobotanical data were collected through interviews with 203 participants. The data associated with threatened plant's population size were gathered through literal counting of individual plants as per the IUCN's Red List Criteria. Data associated with the conservation statuses were gathered from both the South African National Biodiversity Institute and IUCN databases.

A total of 13 useful threatened plants belonging to 12 families were recorded with their conservation statuses ranging from being Vulnerable to Critically Endangered. The majority of the threatened plant species (46.0%) were used for medicinal purposes only, followed by species used for medicinal purposes and as ornamentals (23.0%). The frequently cited useful threatened species with use values (UV) > 0.024, relative frequency citation (RFC) > 0.059 and fidelity level percentage (FL%) > 5.911%, included *Asparagus sekukuniensis*, *Bowiea volubilis*, *Brackenridgea zanguebarica*, *Ocotea bullata*, *Rhynchosia vendae*, *Siphonochilus aethiopicus* and *Warburgia salutaris*. About 47.0% of the recorded useful threatened plants were distributed in remote areas of the Thathe Vondo and its surroundings. Threatened plants with population size < 100 adult individuals constituted the majority (61.54%).

Birdlime-making plant species were also documented in the current study. A total of 12 birdlime-making plants belonging to six families were recorded, including threatened *Huernia nouhuysii*, which is categorized as Vulnerable in South Africa. Amongst the recorded families, Loranthaceae and Euphorbiaceae were categorized as the most frequently utilized families. Among the recorded species, six of them were reported to being used in the birdlime-making for the first time and these species include *Euphorbia pulvinata* (17.2%), followed by *Tapinanthus forbesii* (8%), *Tapinanthus rubromarginatus* (7.2%), *Erianthemum ngamicum* (7.2%), *Englerophytum magalismon-tanum* (3.6%), *Huernia nouhuysii* (2.0%), and *Euphorbia tirucalli* (0.8%). Only three plant parts were utilized for birdlime-making. The milky latex was preferred plant part (58.3%), followed by fruit (33.3%) and root bark (8.4%). Birdlime-making techniques involved crushing, which accounted for 55.7%, followed by air blown (29.6%) and boiling (14.7%). Furthermore, the complementary contribution of birdlime toward human development included, being used for bird hunting or trapping small birds (45.8%), adhesion (23.2%), teeth cleaning (17.2%) and roof-waterproofing (13.8%).

The indigenous conservation strategies employed by participants included harvesting of single lateral root per individual medicinal plant (15.3%), medicinal and timber materials are only harvested during winter season (16.7%), the use of moist soil to cover injured plant part after bark harvest (18.2%), prohibit harvesting of and/ or from an injured plant (11.8%), collection of dried or fallen plants for firewood (8.4%), issuing of permits by traditional council through the chief or headman to allow collection of medicinal materials and timber (9.9%), prohibit chopping down of medicinal plant species (13.8%) and collection of some Critically Endangered plant species such as *Brackenridgea zanguebarica* and *Siphonochilus aethiopicus* during the night by authorized people only (5.9%).

The hypothesis which stated that traditional knowledge about utilization, distribution and conservation statuses of threatened plant species provide suggestions for appropriate conservation practices can therefore, not be rejected as there is room for further and more detailed ethnobotanical investigations that is focused on human interactions with threatened plant species. The data presented in this thesis could be used as baseline information for formulating new conservation strategies, monitoring and management plans of threatened plant species not only in the Vhembe Biosphere Reserve, but in other regions of South African. This study provided insights associated with ethnomedicinal uses of *Asparagus sekukuniensis*, *Protea laetans* and *Encephalartos hirsutus*. Results of this study could also stimulate interest in other scientific disciplines such as the phytochemistry, pharmacology, bioprocessing, conservation and anthropology involving documentation threatened plant species.

Keywords: Birdlime-making, distribution, indigenous conservation strategies, population size, threatened plant species, utilization, Vhembe Biosphere Reserve.

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CHAPTER ONE

GENERAL INTRODUCTION

Chapter One: General introduction

Thematic background

Threatened plants are those species that are vulnerable or at the risk of extinction. According to Version 3.1 of the International Union for Conservation of Nature's (IUCN) Red List Categories and Criteria, the three categories of threat in order of increasing risk of extinction are: Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) (IUCN, 2017; IUCN, 2012; IUCN, 2021). These species are protected by both national and international obligations (Messer, 2010; Trouborst, 2010). In South Africa, threatened plant species are protected under Section 56 and 57 of the National Environmental Management Act No. 10 of 2004 (Republic of South Africa, 2004). Internationally, threatened plant species are protected through treaties and international conventions (Cock et al., 2010; de Oliveira et al., 2011). Therefore, the United Nations Convention on Biological Diversity (CBD) provides guidance associated with uses of genetic resources and traditional knowledge (Talaat, 2013). The entire protocol is devoted to the access of resources, fairness and equitable benefit-sharing (Buck and Hamilton 2011). Literature evidence showed that many threatened plant species in South Africa and worldwide are exposed to extinction risk (Jackson and Kennedy, 2009; Reed et al., 2011). Human disturbance is known to be among the factors that accelerated the pace of species extinction and therefore, the current extinction rate was estimated to be approximately 1000 times than normal rates (Lenzen et al., 2012; Pimm et al., 2014). The population size of threatened plants in the Vhembe Biosphere Reserve, Limpopo province, South Africa is declining at a rapid pace (Tshisikhawe et al., 2013). The current expansion of agricultural land, urbanization, over-exploitation of biological resources, climate change and invasive alien species are regarded as major drivers of biodiversity loss and high rate of species extinction worldwide (Egoh et al., 2009; McGeoch et al., 2010; Giam et al., 2010; Joppa et al., 2011; Pacifici et al., 2015; Mullu, 2016; Courchamp et al., 2017). An approximately one-third of global pristine ecosystems have been transformed for human usage (Davies et al., 2011). There is no doubt that people have altered the functionality of ecosystem as compared to any living species (Purvis and Hector, 2000; Rodríguez et al., 2011; Blackburn et al., 2014). The increasing need for commercial trading of medicinal plants at both local, national and international level is another factor pushing threatened plant species towards the edge of extinction risk (Moeng and Potgieter, 2011; Van Andel et al., 2012; Towns et al., 2014).

The threatened plant species decline cannot negatively impact biodiversity and its ecosystems only, it could also disrupt the provision of ecosystem services to poor and marginalized communities, whom they mostly depend on such services for livelihoods and the provision of primary health care (Schatz, 2009). Threatened plant species in Limpopo Province, particularly in the Vhembe Biosphere Reserve are also prone to the impacts of climate change, ecosystem transformation, droughts and needs for rural development (Ofoegbu et al., 2016). According to Keith et al. (2008), species response to climate change could be influenced by habitat degradation, fragmentation and edge effect. The vulnerability of plant species to extinction risk increases with the decrease in their population size and area of occupancy (Gaston and Fuller, 2009). The narrower the distribution size, the more likely chance to face extinction risk. Newbold (2010), emphasize that the baseline to fully understand species extinction, is to be familiarized with their conservation status. Despite the continual biodiversity loss at the global level, South Africa has endorsed the National Environmental Management Regulations to help protect its threatened species (Waples et al., 2013). However, these regulations denied local people access to their surrounding wildlife and also subsistence utilization of plant resources (Reid et al., 2004). Although, these regulations were meant to promote biodiversity conservation, it also increases poaching of botanical resources of high conservation concern at the local level. Human perceptions about conservation and sustainable uses of plant resources are steadily evolving worldwide (Tassin and Kull, 2015). Araia and Chirwa (2019a), uttered that local people in the Vhembe Biosphere Reserve, mostly conserve natural resources for their own benefits. Nevertheless, local people in the Vhembe Biosphere Reserve have been conserving botanical resources, including those that are threatened for their subsistence uses (Araia and Chirwa, 2019b). Moreover, literature studies suggest that conservation and utilization of natural resources, interlinked together (Heywood and Iriondo, 2003; Tshisikhawe, 2016). Such interlink, could significantly be used to enhance the fight against extinction risks (Biró et al., 2014). The indigenous knowledge system that interlinks conservation and utilization of botanical resources is equally important for new drug discovery, sustaining the traditional health care system and livelihood in rural communities (Maroyi, 2008; Mesfin et al., 2013; Maroyi, 2016). The indigenous conservation practice is considered baseline for strategic conservation planning (Bamigboye et al., 2017). About 200 000 traditional healers in South Africa rely upon plant species for medicines (Xego et al., 2016), and therefore, there is no doubt that some of these species considered to be plants of high conservation concern. Threatened plant species in South Africa are being harvested for medicinal purposes and other social uses (Williams et al., 2013).

Problem statement

Despite the fact that the Vhembe Biosphere Reserve, of the Limpopo province, is a biodiversity hotspot (Kirchhof et al., 2010; Hahn, 2016; Hahn, 2017), it is also one of the least studied region in South Africa (Vhembe Biosphere Reserve, 2012). Although, the Vhembe region was declared a biosphere reserve by the United Nation Educational, Scientific and Cultural Organization (UNESCO) in 2009, still to date, there is no clear management and monitoring plans for threatened plant species, and therefore, there is also paucity, rather scant information about spatial information related to threatened plant species distribution in the region. Scientific evidence suggests that the lack of detailed knowledge, particularly spatial information related to threatened plant's location of the distribution, negatively impact their management and monitoring plans (Loko et al., 2017; Van der Biest et al., 2020). In this regards, it is therefore arguable that the establishment of monitoring and management plan for threatened plant species in the Vhembe Biosphere Reserve could remain difficult, even during its second 10 years life circle review, which was initiated during the year 2020, if detailed information about utilization, conservation status, population size and spatial information related to the distribution of these species is still lacking. There is a shortage of scientific studies about indigenous knowledge associated with biodiversity values to human development, not only in the Vhembe Biosphere Reserve, but also in all South African biosphere reserves (Jauro et al., 2020). Although there are many threatened plant species recorded on the IUCN and SANBI databases (Raimondo et al., 2009; IUCN, 2012), their values to human development in context to socioeconomic, sociocultural and socioeconomically have not yet received enough attention. Many people in rural communities are dependent to plant resources for their daily subsistence and livelihoods (Sigidi et al., 2016; Maroyi, 2018).

Indigenous people in the Vhembe Biosphere Reserve have been utilizing plant species, regardless of their conservation status since time memorial. Despite the scientific notion that states that the conservation and sustainable utilization of natural resources are interlinked together and inextricable (Heywood and Iriondo, 2003), indigenous people in Vhembe Biosphere Reserve have long-time ago, declared the necessity to enhance sustainability of plant resources against harvesting pressure and extinction risk using traditional norms, taboos, folk tales and establishment of scary and holy forests. However, the current legislative regulations and South African government policies for conservation and protection of threatened plant species does not cater for local developmental needs or either recognize indigenous knowledge associated with sustainable utilization and indigenous conservation of local biodiversity. Despite the endorsement of indigenous conservation practices, sustainable utilization and equitable sharing of biological resources on Article 1 and 10 of the United Nation Charter for Convention on Biological Diversity (CBD) as well as on Section 24 of the Chapter 2: Bill of Rights, of the constitution of the Republic of South Africa (RSA) (United Nations, 1992; Constitution of South Africa, 1996), still to date, South African government never legitimize indigenous knowledge in resolving conservation issues. However, recent literature studies suggest that scientific knowledge could not be the only knowledge to grant sustainable future and solutions about conservation and species extinction (Sinthumule and Mashau, 2020). As like the failed global efforts to halt out human induced extinction in 2020 (McCarthy et al., 2012), the use of strict conservation measures to enforce compliance in South Africa has shown a great failure (Ofoegbu and Chirwa, 2019).

Rationale and justification

There has been no study of this nature in the Vhembe region since its first proclamation as a biosphere reserve by the UNESCO in 2009. The current study could potential present essential baseline data required to understand and initiate systematic management of threatened plant species in the Vhembe Biosphere Reserve and also for integrating indigenous knowledge into the national conservation agenda. Since indigenous people are known to conserve plant species for their own benefits (Araia and Chirwa, 2019a; Araia and Chirwa, 2019b; Thomson et al., 2020), documentation of detailed information about threatened plant species utilization, conservation status, population size and distribution in the Vhembe Biosphere Reserve are of great interest. This could improve their regional management. Jauro et al. (2020), noticed the gap of indigenous knowledge associated with biodiversity values to human development in South African biosphere reserves. Therefore, the current study is intended to bridge that gap in the Vhembe Biosphere Reserve, of the Limpopo province, South Africa. Enforcing compliance of conservation regulations at national level has never yielded any results in South Africa (Ofoegbu and Chirwa, 2019). Consequently, local people in the Vhembe Biosphere Reserve still prefer the rule of customary laws. Therefore, documentation of indigenous knowledge associated with conservation of botanical resources is not only important for integrated threatened plant conservation and monitoring plans, but equally importance for strengthening compliance and conservation at the local level. Keith et al. (2013), emphasize that insight information, knowledge and understanding are necessity for the integrated action plan.

Therefore, little has been done about the action plan to help strengthen monitoring and management of threatened plant species in the Vhembe Biosphere Reserve since its proclamation. Indigenous conservation knowledge resembles the capability, knowledge attributes and skills that local people possessed (Makgopa and Frangton, 2016). Therefore, such knowledge and skills are still prevalent and it could be used to minimize the rate at which threatened plant species disappeared. The novelty of this study is based on comprehensive ascertaining and documentation of threatened plant species utilization, spatial distribution data and prospects for conservation. There is a need for radical prospects of conservation mechanisms and utilization of threatened plant species in the Vhembe Biosphere Reserve to enhance the present knowledge. This study is intended to inform the lawmakers, scientific community and conservation managers about utilized threatened plant species, their conservation status, spatial information associated with the location of their distribution and also the prospects for their conservation in the Vhembe Biosphere Reserve. In addition, this study aligned with Chapter one and chapter 5 of the South African National Development Plan (NDP), Vision 2030, "*Policy making in a complex environment* and *Ensuring environmental sustainability and equitable transition to a low-carbon economy*" (National Planning Commission, 2012).

The research aims

The current study aimed at investigating threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province in South Africa, and also at assessing their local utilization and prospects for conserving these species.

Research questions

This project therein, addressing the following key research questions:

(i) What are the known threatened plants in the Vhembe Biosphere Reserve?

(ii) How are these threatened plant species used including detailed indigenous knowledge about them?

(iii) How can these species be conserved and sustainably utilized?

Specific objectives

The current study is associated with the following specific objectives:

(i) To make an inventory of threatened plant species in the Vhembe Biosphere Reserve,

(ii) To assess the utilization of threatened plant species by local people in the Vhembe Biosphere Reserve and,

(iii) To explore options that can be used for conserving these species.

Hypotheses

Indigenous knowledge about utilization, distribution and conservation statuses of threatened plant species provide suggestions for appropriate conservation practices.

Scope and Limiting factors

Since this study was an exploratory research project, its scope was limited to cover the following aspects respectively: profiling and categorizing threatened plant species according to their IUCN categories of threats, assessing threatened plant species utilization, distribution and prospects of conserving them. However, there are some limitations associated with the current study. Firstly, this study was carried out in the Vhembe Biosphere Reserve and not all parts of this reserve were explored. Hall (2002) and Tomlinson et al. (2007) argued that although research can play a pivotal role in resolving present and future problems, resource constraints remains the challenging factor.

Thesis outline

Although this thesis report was prepared in a traditional way, it is divided into six chapters respectively, and therefore, each chapter contain its own list of references. The following are outline for the thesis Chapters:

(i) **Chapter 1:** This chapter deals with the introductory part of the study,

(ii) **Chapter 2:** This chapter covered the literature review,

(iii) **Chapter 3:** This chapter focused on the study design and methodology parts,

(iv) **Chapter 4:** This chapter entailed the study results,

(v) **Chapter 5:** Detailed the discussion part and,

(vi) **Chapter 6:** Covered conclusion, including contributions to scientific knowledge and recommendations.

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CHAPTER TWO

LITERATURE REVIEW

Chapter Two: Literature review

Biosphere reserves: History and complementary functions

The United Nations Educational, Scientific and Cultural Organization (UNESCO), was established in 1945, and its main mandate was to promote peace, stability and security to all the global nations through education, science and culture (Omolewa, 2007; Petitjean, 2008; Pool-Stanvliet, 2013; Van der Auwera, 2013; Jian-zhong, 2014; Hiromu, 2020). The UNESCO's Man and Biosphere Program (MAB) has originated as an outcome of the Biosphere Conference held in Paris, the City of France in 1968 (Pool-Stanvliet, 2013). The MAB Program was officially launched in 1970 by the UNESCO (Bonnes et al., 2004; Bridgewater, 2016; Reed, 2019; Rispoli and Olšáková, 2020). The Biosphere Conference resolutely declared the notion that state utilization and conservation of natural resources go hand-in-hand and are inextricable (Pool-Stanvliet, 2013). The UNESCO's Man and Biosphere Program are considered an intergovernmental programme and interdisciplinary science program (involving social, natural, biological and physical sciences) based on problem-solving research and action zeroed in on enhancing human-environmental relations (Reed, 2016). The MAB Program provides guidelines required to encourage the creation of biosphere reserves in all the biogeographic regions throughout the globe (Pool-Stanvliet, 2013). The MAB fosters for the harmonious coexistence of people and environment to achieve sustainable development through improving human well-being, participatory dialogues, reduction of poverty, knowledge-sharing, mutual respect for cultural values and the society's ability to cope with time and change (UNESCO, 2019a). The authorities to designate biosphere reserves are held by the UNESCO, and therefore all biosphere reserves are part and parcel of the World Network of Biosphere Reserves (WNBR), which was established in 1976 (Bridgewater, 2002; Lotze-Campen et al., 2008; Bridgewater and Babin, 2017). The World Network of Biosphere Reserves herein defined as the collaborative or communication network between the UNESCO biosphere reserves and therefore, its mandates is to promote south-to-south and north-to-south collaborations and it is therefore, considered an exceptional tool for enhancing international co-operation through knowledge-sharing, capacity building, exchanging experiences and promotion of ethical practices (UNESCO, 2019a).

A biosphere reserve herein defined as an international recognized areas of either costal, marine or terrestrial ecosystems and its main purpose is to reconcile the conservation of biodiversity with its uses, and also to promote sustainable development, while, harmonizing the coexistence of humans and nature (Price, 2002; Ishwaran et al., 2008; Price et al., 2010; UNESCO, 2017; Van Cuong et al., 2017; Kratzer, and Ammering, 2019; Reed, 2019). Lafortezza et al. (2018) and Mondino and Beery (2019), considered the biosphere reserves as the living laboratories and areas that provides a local-based solution to the global challenges (Heinze et al., 2020). Thus, includes the use of indigenous knowledge systems in the provision of innovative solutions to global challenges (Morris and Rushwan, 2015; Tengö et al., 2017). Since the official launch of the MAB Program in 1970 (Bridgewater, 2016; Reed, 2019), the establishment of biosphere reserves has shown a tremendous growth, and so far, there are 714 biosphere reserves in 129 countries across the globe (UNESCO, 2019a), with 84 biosphere reserves found in 31 African countries (UNESCO, 2019b). Amongst the 84 African biosphere reserves, 10 of them are found in South Africa, including, Cape West-Coast Biosphere Reserve, Wateberg, Kruger-to-Canyons, Cape Winelands, Vhembe, Gouritz Cluster, Magaliesberg, Garden Route and Marico (Lyon et al., 2017; UNESCO, 2019b; Pool-Stanvliet et al., 2018). South African biosphere reserves covered the total surface area of approximately 11 757 326 ha (Pool-Stanvliet et al., 2018). Therefore, the Gouritz Cluster Biosphere Reserve is considered to be the largest biosphere reserve in South Africa, covering the total surface area of about 3 187 893 ha, followed by the Vhembe Biosphere Reserve, with the surface area of approximately 3 070 100 ha (GCBR., 2018; Pool-Stanvliet et al., 2018; Vhembe Biosphere Reserve, 2019). Evidence shows that it has been more than five decades since the establishment of MAB by the UNESCO, yet biosphere reserves remain understudied, underutilized and undervalued, with their roles not yet fully understood by governments and the public in general (Van Cuong et al., 2017; Pool-Stanvliet and Coetzer, 2020). This highlighted the need for multi-disciplinary studies in the biosphere reserves worldwide, and in South African biosphere reserves (Jauro et al., 2020).

The fundamental focus of the biosphere reserves are based on serving three complementary functions, including (i) conservation (of ecosystems, landscapes, as well as biological species and their genetic variations), (ii) sustainable development (promoting economic developments which are socio-ecological and sociocultural sustainable), and also (iii) logistical support (fostering monitoring, research, education and training) (Elbakidze et al., 2013; Pool-Stanvliet, 2013; UNESCO, 2019a). The success of a biosphere reserve is based on understanding and implementation of its complementary functions in a demarcated landscape zoned to promote the bioculture conservation and sustainable use of natural resources in the form of core, buffer and transitional zones (Kušová et al., 2008; Van Cuong et al., 2017; Pool-Stanvliet et al., 2018). The core zone herein defined as an area in which human disturbance is absolutely restricted. This area is demarcated to promote diverse species conservation and therefore, it is characterized by suitable habitats to allow all its species flourish in every way possible (Dutta et al., 2010; Flores-Martínez et al., 2019). The buffer zone is considered an area that divides the core and transitional area. Although minimal disturbance is permitted with high level of vigilance within the buffer area, its main purpose is to protect the core area against any form alteration (Tesfahunegny et al., 2016; Bridgewater and Babin, 2017; M'Woueni et al., 2019). The transitional zone is defined as the dwelling region, whereby many forms of development, including settlements, farming, construction and mining are permitted, but still regulated (Saranya and Reddy, 2016; Stoll-Kleemann and O'Riordan, 2017; Wondimagegnhu et al., 2019). This area serves as an entry-point to the biosphere reserve, and also as getaway-point from the reserve. The functionality of every biosphere reserve is evaluated in a period of ten years, and therefore, this process is called Periodic Review (Castaño-Quinteroa et al., 2017; Matar and Anthony, 2018), and it was adopted by the UNESCO's General Assembly as part and parcel of the Seville Strategy (Price, 2017; Kratzer2018), under the Statutory Framework of the World Network of Biosphere Reserves (Schliep and Stoll-Kleemann, 2010; Köck and Arnberger, 2017; Van Cuong et al., 2017).

Legal framework pertaining threatened plant species

In South Africa, the authority for assessing or re-assessing the conservation status of threatened plant species is held by South African Biodiversity Institute (SANBI), which is an affiliate to the International Union for Conservation of Nature (IUCN) (Moraswi et al., 2019; Bamigboye, 2019). The IUCN is an international organization, that holds international mandates and authority for categorizing threatened plant species according to their categories of threats, and also give accreditations and directives to all its affiliates worldwide (Callmander et al., 2005; Rodrigues et al., 2006; Hoffmann et al., 2008). Threatened plants herein defined as species that have been holistically assessed using Version 3.1 of the IUCN's Red List Categories and Criteria, and consequently awarded the conservation status as either, Vulnerable (VU), Endangered (EN) or Critical Endangered (CR) (IUCN, 2012; Williams et al., 2013; Dzerefos et al., 2017; Du et al., 2018; Bamigboye and Tshisikhawe, 2020). Some scholars referred threatened plants as species of high conservation concern (Keller and Bollmann, 2004; van Swaay et al., 2011; Tiawoun et al., 2018; Tiawoun et al., 2020). South Africa has endorsed many strict regulations to help conserve threatened plant species at the national level and therefore, these regulations includes, the Conservation of Agricultural Resources Act No. 43 of 1983, National Forests Act No. 84 of 1998, National Environmental Management Act No. 107 of 1999 and National Environmental Management: Biodiversity Act No. 10 of 2004 (Ndlela, 2004; Foden, 2007; Crouch and Smith, 2010; Knobel, 2015; Dzerefos et al., 2017; Bamigboye et al., 2017). However, scientific evidence suggests that such regulations in South Africa likely denies local people access to their surrounding wildlife and direct subsistence benefits (Reid et al., 2004). On the contrary, the international protection of threatened plant species is endorsed by the United Nations (UN), through international treaties and conventions, including an international treaty on Plant Genetic Resources for Food and Agriculture, Convection on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and International Plant Protection Convention (Korsmo, 1991; Havens et al., 2006; Messer, 2010; Kahler and Gore, 2012; Eschen et al., 2015; Bazile et al., 2016; Biggs et al., 2017; Afriansyal and Ardiastuti, 2017; Halewood et al., 2018). Therefore, Article 1; 8 (j) and 10 of the UN charter on the Convention for Biological Diversity gives full recognition to local indigenous people and their knowledge regarding sustainable uses of genetic resources (Talaat, 2013; Sinthumule and Mashau, 2020). The entire convention is devoted to access to genetic materials, fairness and equitable sharing of benefits arising from natural resources (Buck and Hamilton, 2011; Flach et al., 2019; Knauf et al., 2019). It is, therefore arguable that South African regulations pertaining plant species protection likely violet Article 1; 8 (j) and 10 of the UN's Charter on Convention for Biological Diversity (United Nations, 1992), and Section 24 of the Chapter 2: Bill of Right, of the constitution of the Republic of South Africa (Constitution of South Africa, 1996).

Disappearance of threatened plant species

Scientific evidence shows that many threatened plant species are disappearing at an alarming rate worldwide (Reed et al., 2011; Rivers et al., 2011; Maroyi, 2012; Tshisikhawe et al., 2013; Ibrahim et al., 2013; Borokini, 2014; Brummitt et al., 2015; Volis, 2016; Magee et al., 2017; Fox and Madsen, 2017; Davison et al., 2018; Pykälä, 2019; Bello et al., 2019). This is mainly caused by varying factors, including climate change, agricultural land expansion, over-exploitation of biological resources for commercial purpose, alien invasive species and habitat transformation due to on-going urbanization (Baider and Florens, 2011; He and Hubbell, 2011; De Baan et al., 2013; Rey et al., 2016; Van Wyk and Prinsloo 2018; Tiawoun et al., 2019; Woinarski et al., 2019). The disappearance of plant species could in turn disrupt the provision of ecosystem services. This can negatively affect human's well-being, livelihood chain and sociocultural relations, especially in third-world countries, including South Africa (Scholes, 2016; Pascual et al., 2017; Liu and Krutovsky, 2018; Debnath et al., 2020). Many people in third-world countries are dependent to natural resources, supplied as ecosystem services (Paudyal et al., 2017; Boone et al., 2018; Ngwenya et al., 2019; Castro-Díez et al., 2019; Chaplin-Kramer et al., 2019). Globally, scientists warn that ignorance to present species extinction can accumulate into the mass extinction event (Mitchell, 2018). Furthermore, although there are many predictions about the present species extinction rate (Lenzen et al., 2012; Pimm et al., 2014), scientists again warn that the pragmatic extinction rate could likely exceed the predicted rates (Valiente-Banuet et al., 2015). To counteract the risk of species extinction, the international community through various government initiatives have devoted to halt, rather minimize human-induced extinctions (McCarthy et al., 2012). Due to this, governments throughout the world are making the conservation of biological species, including threatened plants mandatory and priority in all their spheres (Rossi et al., 2016; Brundu et al., 2017; Dzerefos et al., 2017). Over the last decades, government spending on the fight against species extinction, have immensely increased (Ma et al., 2013), and therefore, Sheil et al. (2013) estimated the global cost used in the fight against extinction to exceed US$7.1 billion per annum. Regardless of the allocated budget to expedite the fight against extinction, the rate of species extinction worldwide still remained increasing at the rapid pace, and with no indications to slow down soon (Stern, 2008). Furthermore, conservation mechanisms and strict government protocols presently used to combat species extinction worldwide, have proven to be not robust, insufficient and ineffective (Stern, 2008). As a result, to date non-compliance of conservation protocols has become a common global challenge (Oldekop et al., 2016; Ofoegbu and Ifejika-Speranza, 2017). Similarly to the global failure regarding the pledge to halt-out extinction threats by the year 2020 (McCarthy et al., 2012), the use of strict conservation protocols to enforce compliance in South Africa, also produced no results (Ofoegbu and Chirwa, 2019). Therefore, this has raised many intriguing questions, one being whether scientific knowledge only, could truthfully grant sustainable solutions about extinction threats?.

Indigenous conservation, utilization and distribution of threatened plant species

Indigenous conservation herein defined as an applied traditional knowledge and attributes inherited to help conserve natural resources (Nkwanyana, 2018; Mavhura and Mushure, 2019; Suwardi et al., 2020). Indigenous conservation knowledge has once been considered an important tool to enhance sustainability of useful resources worldwide (Gadgil et al., 1993; Johannes, 2002; Fennell, 2008; Colchester, 2004; Maarif, 2015; Ens et al., 2016), including threatened botanical resources. Davidson-Hunt et al. (2012) and Gavin et al. (2015), uttered that indigenous conservation knowledge could play an outstanding role against species extinction, habitat transformation, over-exploitation and poaching of important botanical resources. Yet, there is inadequate information pertaining indigenous conservation mechanisms used to sustain the viability of threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa, however. Human perceptions about the conservation of their surrounding natural resources are steadily evolving worldwide (Tassin and Kull, 2015). However, in South Africa, the potential of indigenous knowledge systems pertaining conservation of botanical resources, mainly in the African context, remain denounced, rejected and ignored (Mutshinyalo and Siebert, 2010). The denounced indigenous conservation knowledge remains anecdotal and circumstantial to date. Therefore, it is worthwhile reiterating that, although the apartheid regime collapsed in about two and half decades ago, the denounced heathen indigenous conservation culture, mainly, in the African context, has likely left stigmas amongst many South Africans to date. Christie (2006) labelled the former apartheid regime as an institutionalized form of governance used to oppress indigenous people in South Africa, through racial and cultural segregation policies. This could be barriers likely preventing acceptability of indigenous conservation culture and its way to enforce compliance as an alternative towards achieving meaningful conservation at the local level countrywide. Teffo (2011) highlighted the notion of integrated conservation approach as it could bring the fulfilling results if it is to be applied countrywide. Indigenous conservation mechanisms could be better perceived as an alternative towards enhancing the fight against species extinction (Teffo, 2019), and also as a pathway towards achieving the measurable Goals for Sustainable Development, (Garrity, 2004; Reed et al., 2006; Sachs, 2012; Caiado et al., 2018). Therefore, this includes Goal 13 and 15 that emphasizes the issue of combating climate change and its impacts, conserving forest resources and also preventing the loss of biodiversity (Sachs, 2012). Various scholars perceived indigenous conservation approach as useful against biodiversity loss (Van Schie and Haider, 2015; Daninga et al., 2015). According to Mutshinyalo and Siebert (2010), indigenous conservation knowledge is substantial for minimizing the threats of extinction.

Recent literature studies suggest that scientific knowledge could not be the only knowledge to grant sustainable future and solution about conservation and species extinction (Sinthumule and Mashau, 2020). Moreover, scientific studies also suggested that indigenous people through indigenous knowledge systems have been engaged in biodiversity conservation and species monitoring since time immemorial (Thompson et al., 2020; Bahagia et al., 2020). However, scientific literatures also suggest that indigenous people usually monitored, to conserve natural resources for their own benefits (Araia and Chirwa, 2019a; Thomson et al., 2020). Due to thus, Salafsky et al. (2002) and Hywood and Iriondo (2003), emphasized that utilization and conservation of natural resource are inter-linked together and inextricable. Indigenous knowledge herein defined as applied cumulative knowledge and attributes inherited and subsequently passed through generationally patterns (Mavhura et al., 2013; Bamigboye et al., 2017; Nkwanyana, 2018; Suwardi et al., 2020). Consequently, local people in some tribal areas, including dwellers of the Vhembe Biosphere Reserve, in the Limpopo Province, South Africa have voluntarily taken the fight to minimize the risk of species extinction, through the use of various indigenous conservation mechanisms (Ofoegbu and Chirwa, 2019; Araia and Chirwa, 2019a). However, a lot of indigenous conservation knowledge in the Vhembe Region is still transferred orally and documented nowhere. Despite the thriving literature about indigenous conservation practices worldwide (Fernández-Llamazares and Cabeza, 2018; Garnett et al., 2018), recent scientific evidence suggests that such studies remain lacking in South African Biosphere Reserves (Jauro et al., 2020). Consequently, many studies done in the Vhembe Biosphere Reverse likely focused their attention on indigenous medicinal aspects (Nelwamondo et al., 2013; Luseba and Tshisikhawe, 2013; Tshisikhawe et al., 2014; Magwede et al., 2014; Masevhe et al., 2015; Ramovha, 2016; Ramovha and van Wyk, 2016; Tshidzumba, 2018; Magwede et al., 2019a; Mokganya and Tshisikhawe, 2019), leaving the issue of indigenous conservation untapped.

This has resulted in minimal number of studies done about indigenous conservation, monitoring and compliance in the region (Mutshinyalo and Siebert, 2010; Semenya et al., 2013; Araia and Chirwa, 2019b; Sinthumule and Mashau, 2020). Lawmakers, conservation managers and scientists are now considering options for integrating indigenous conservation means into the mainstream conservation agenda (Araia and Chirwa, 2019a; Bahagia et al., 2020). This, emphasize the need to properly review documented information about indigenous conservation, monitoring and management of threatened plant species in South African Biosphere Reserves, including the Vhembe Biosphere Reserve.

The notion that conservation and sustainable utilization of natural resources are inextricable and interlinked together is widely accepted (Heywood and Iriondo, 2003; Pool-Stanvliet, 2013; Tshisikhawe, 2016). Global interest on indigenous knowledge researches, especially, these involving utilization and conservation is growing immensely (Kunz et al., 2012; Tareen et al., 2016; Ndhlovu et al., 2019; Astutik et al., 2019; Setshego et al., 2020). This clearly accentuates the positive impact that indigenous knowledge have in resolving issues that affect social life, including socio-ecological and socio-economic issues. Scientific scholars, including, botanists, ethnobotanists, economic-botanists, conservationists and anthropologists, all share common interest about the use of indigenous knowledge for livelihoods, scientific and economic growth (Sinthumule and Mashau, 2020). During the last decade, documentation of African indigenous knowledge associated to conservation and utilization of natural resources has shown a tremendous growth (Maroyi, 2013a; Williams et al., 2013; Borokini, 2014; Leonard and Viljoen, 2015; Cunningham et al., 2016; Dzerefos et al., 2017; Semenya and Maroyi, 2019a). Local people in the Southern African Region, including dwellers of the Vhembe Biosphere Reserve, in Limpopo Province, South Africa, have been conserving botanical resources for the purpose of obtaining maximum subsistence benefits for many years (Araia and Chirwa, 2019b). Therefore, scientific evidence shows that some of these benefits were obtained from threatened botanical resources distributed in their dwelling regions (Mabogo, 1990; Williams et al., 2013; Magwede et al., 2019b). Mostly ethnobotanical studies pertaining threatened plant species in the Southern African Region focused on medicinal aspects (Makunga et al., 2008; Mankga et al., 2013; Veeman et al., 2014; Brueton, 2014; Salmina, 2017; Aremu et al., 2015; Rusethe et al., 2019; Van Wyk and Prinsloo, 2019; Semenya and Maroyi, 2019c; Cock and Van Vuuren, 2020; Adebayo et al., 2020; Leonard et al., 2020; Komakech et al., 2020; Veldman et al., 2020; Galabuzi et al., 2021).

Furthermore, in South Africa, Williams et al., (2013), also documented the medicinal aspects of threatened plant species. This has raised many intriguing questions, one being whether threatened plants in Southern Africa, including in South Africa are only utilized for medicinal purpose? However, in the Vhembe Biosphere Reserve, local indigenous knowledge associated to utilization of threatened plant species for subsistence, rather than livelihoods and economic growth have not yet fully explored. Ethnobotanical studies about threatened plant species in this region, mostly focused on *Brackenridgea zanguebarica* Olive., (Tshisikhawe. and Van Rooyen, 2012; Tshisikhawe, 2016; Tiawoun et al., 2018; Tiawoun et al., 2020). This has also raised many exciting questions on whether *B. zanguebarica* is the only utilized threatened plant species in the entire region or not?, if not, what are the other utilized threatened plants in the region?, where are these other utilized threatened plant species distributed in the region?, what is their conservation status?, and what are they used for, by local people?. Literature studies suggest that local people of the Vhembe Biosphere Reserve, in Limpopo Province, South Africa have been adjusting their subsistence needs with biodiversity conservation and sustainable utilization of natural resources since time immemorial (Araia and Chirwa, 2019b). However, little remains known about the indigenous conservation mechanisms used by local people in the region (Araia and Chirwa, 2019a). Spatial information about local distribution of many threatened plant species in the region and their actual or specific uses are also not known. Therefore, scientific evidence suggests that lack of spatial information about distribution of certain species or species of high conservation concern can negatively impact their management and monitoring plan of these species (Brodnig and Mayer-Schönberger, 2000; Meredith et al., 2002; Driver et al., 2005; Bottero et al., 2013; Selig et al., 2014; Garnett et al., 2018; Harlio et al., 2019; Van der Biest et al., 2020). As a result, this could hinder the existing conservation efforts devoted to sustainability of threatened plant species in the region regardless of either the effort is conventional or non-conventional in its nature. Table 2.1, is the review of utilized threatened plant species in the Limpopo Province, whereas, table 2.2, illustrates a review of utilized species in the Vhembe Biosphere Reserve. Finally, table 2.3, reviewed the distribution of utilized threatened plant species in the Vhembe Biosphere Reserve, countrywide and elsewhere.

Table 2.1: Utilized threatened plant species and their conservation status in the Limpopo Province, South Africa

Family	Botanical name	Conservation status	Plant category	Use category	Used parts	References
Apiaceae	*Alepidea amatymbica* Eckl. & Zeyh.	EN	Herb	Medicinal and magic	Root and whole plant	Raimondo et al., 2009; Maroyi, 2016; Rasethe, 2017; Semenya and Maroyi, 2018a; Rasethe et al., 2019; Semenya and Maroyi, 2019b; Semenya and Mokgoebo, 2020
Apocynaceae	*Mondia whitei* (Hook.f.) Skeels	EN	Herb	Medicinal	Root and fruits	Raimondo et al., 2009; Aremu et al., 2011; Rasethe, 2017; Cock et al., 2018; Rasethe et al., 2019;
Apocynaceae	*Ceropegia cimiciodora* Oberm.	VU	Herb	Medicinal		Raimondo et al., 2009; Mine, 2016; Tiawoun et al., 2018
Canellaceae	*Warburgia salutaris*	EN	Tree	Medicinal	Bark	Raimondo et al., 2009; Rasethe, 2017; Semenya and Maroyi, 2018b; Semenya

	(G.Bertol.) Chiov.					and Maroyi, 2019b; Rasethe et al., 2019; Adebayo et al., 2020
Cucurbitaceae	*Cucumis humifructus* Stent	VU	Herb	Medicinal	Whole plant	Raimondo et al., 2009; Tiawoun et al., 2018; Welcome and Van Wyk, 2019
Dioscoreaceae	*Dioscorea sylvatica* Eckl.	VU	Herb	Medicinal	Bulb	Raimondo et al., 2009; Rasethe, 2017; Rasethe et al., 2019; Semenya and Maroyi, 2019b
Fabaceae	*Rhynchosia vendae* C.H.Stirt.	VU	Climber	Medicinal		Raimondo et al., 2009; Tiawoun et al., 2018; Welcome and Van Wyk, 2019
Lauraceae	*Ocotea bullata* (Burch.) Baill.	EN	Tree	Medicinal	Bark	Raimondo et al., 2009; Mankga et al., 2013; Tiawoun et al., 2018; van Wyk et al., 2019; Van Wyk and Prinsloo, 2019; Adebayo et al., 2020
Lauraceae	*Ocotea kenyensis* (Chiov.)	VU	Tree	Medicinal	Bark	Raimondo et al., 2009; Mostert et al.,

	Robyns & R.Wilczek					2008; Roux, 2018; Tiawoun et al., 2018
Liliaceae	*Bowiea volubilis* Harv. ex Hook.f.	VU	Herb	Medicinal	Bulb	Raimondo et al., 2009; Makunga et al., 2008; Mankga et al., 2013; Brueton, 2014; Aremu et al., 2015; Rasethe, 2017; Rasethe et al., 2019; Van Vuuren and Frank, 2020
Rosaceae	*Prunus africana* (Hook.f.) Kalkman	VU	Tree	Medicinal and timber	Bark and stem	Raimondo et al., 2009; Mankga, 2012; Rasethe, 2017; Tiawoun et al., 2018; Van Wyk and Prinsloo, 2019; Semenya and Maroyi, 2019b; Rasethe et al., 2019; Cock and Van Vuuren, 2020
Rutaceae	*Brackenridgea zanguebarica* Oliv.	CR	Tree	Medicinal and magic	Bark and root	Raimondo et al., 2009; Rasethe, 2017; Semenya and Maroyi, 2019b; Rasethe et al., 2019; Semenya and Mokgoebo, 2020
Zamiaceae	*Encephalartos dolomiticus*	CR	Cycad	Ornamental and	Whole plant and	Raimondo et al., 2009; Rousseau, 2012; Williamson et al., 2016; Tiawoun et al.,

	Lavranos & D.L.Goode			medicinal	corns	2018
Zamiaceae	*Encephalartos eugene-maraisii* I.Verd.	EN	Cycad	Ornamental and corns	Whole plant and corns	Raimondo et al., 2009; Rousseau, 2012; Williamson et al., 2016; Okubamichael et al., 2016; Tiawoun et al., 2018
Zamiaceae	*Encephalartos hirsutus* P.J.H.Hurter	CR	Cycad	Ornamental and medicinal	Whole plant and corns	Raimondo et al., 2009; Cousins et al., 2011; Rousseau, 2012; Cousins and Witkowski, 2017; Tiawoun et al., 2018; Welcome and Van Wyk, 2019
Zamiaceae	*Encephalartos laevifolius* Stapf & Burtt Davy	CR	Cycad	Ornamental and medicinal	Whole plant and corns	Mabunda, 2007; Raimondo et al., 2009; Cousins et al., 2011; Rousseau, 2012; Cousins et al., 2013; Tiawoun et al., 2018
Zingiberaceae	*Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt	CR	Tree	Medicinal and magic	Bulb	Raimondo et al., 2009; Fouche et al., 2011; Rasethe, 2017; Salmina, 2017; Semenya and Maroyi, 2018a; Semenya and Maroyi, 2019b; Gatabazi, 2019;

						Rasethe et al., 2019; Adebayo et al., 2020

Table 2.2: Utilized threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. [Keys: A_{1} = Magwede et al. (2019a); A_{2} = Mphephu (2017); A_{3} = Nefhere (2019); A_{4} = Mashimbye et al. (1999); A_{5} = Mabogo (1990); A_{6} = Van Wyk and Van Wyk (1997); A_{7} = Ojelade (2018); A_{8} = Tshisikhawe (2013); A_{9} = Tshisikhawe. and Van Rooyen (2012); A_{10} = Tshisikhawe (2016); A_{11} = Tiawoun et al. (2018); A_{12} = Tiawoun et al. (2020); A_{13} = Constant and Tshisikhawe (2018); A_{14} = Hahn (2002); A_{15} = Arnold and Gulumian (1984); A_{16} = Tshisikhawe (2002); A_{17} = Van Wyk et al. (1997); A_{18} = Netshiungani and Van Wyk (1980); A_{19} = Van Wyk and Van Wyk (1997); A_{20} = Tshisikhawe et al. (2013); A_{21} = Sobiecki (2002); A_{22} = Ndhlovu et al. (2019); A_{23} = Magwede (2018); A_{24} = Masevhe et al. (2015); C_{1} = Senkoro et al. (2019); C_{2} = Veeman et al. (2014); C_{3} = Augustino et al. (2011); C_{4} = Maroyi (2000); C_{5} = Brown (2013); C_{6} = Dludlu et al. (2017); C_{7} = Maroyi (2012); C_{8} = Simelane (2009); C_{9} = Cunningham and Mbenkum (1993); C_{10} = Ndam and Marcelin (2004); C_{11} = Tolessa (2019); C_{12} = Mugula et al. (2010); C_{13} = Bellewang (2005); C_{14} = Neimark (2010); C_{15} = Giliba and Yengoh (2020); C_{16} = Gyau et al. (2012); C_{17} = Mwitari et al. (2013); C_{18} = Bandeira et al. (2001); C_{19} = Chhabara et al. (1990); C_{20} = Neuwinger (2000); C_{21} = Möller et al. (2006); C_{22} = Veldman et al. (2020); C_{23} = Singo (2007); C_{24} = Clarke and Dickinson (1995); C_{25} = Bruschi et al. (2011); C_{26} = Palgrave et al. (2007); C_{27} = Conde et al. (2014); C_{28} = Osmaston (1968); C_{29} = Timberlake et al. (2009); C_{30} = Timberlake et al. (2016); C_{31} = Marston et al. (1996); C_{32} = Hostettmann and Marston (2001); C_{33} = Chidhakwa (2003); C_{34} = Nicosia et al. (2020); C_{35} = Bundschuh et al. (2010); C_{36} = Opio et al. (2017)].

Plant species name	**Used categories**	**Used parts**	**Use records**	
			A: Local records (Vhembe Biosphere	**C: Records elsewhere (Other countries)**

			Reserve)	
B. zanguebarica	Medicinal	Bark and root	A_1; A_2; A_3; A_5; A_6; A_7; A_8; A_9; A_{10}; A_{11}; A_{12}; A_{13}; A_{15}; A_{16}; A_{17}; A_{18}; A_{19}; A_{20}; A_{21}; A_{22}; A_{23};	C_{19}; C_{20}; C_{21}; C_{22}; C_{23}; C_{24}; C_{25}; C_{26}; C_{27}; C_{28}; C_{29}; C_{30}; C_{31}; C_{32}; C_{33}; C_{34}; C_{35}
P. africana	Medicinal	Bark	A_1; A_2; A_{23}	C_9; C_{10}; C_{11}; C_{12}; C_{13}; C_{14}; C_{15}; C_{16}; C_{17}; C_{18}; C_{22}; C_{29}; C_{35}
R. vendae	Medicinal	Root tuber	A_1; A_{14}; A_{23}	None
W. salutaris	Medicinal	Bark	A_1; A_2; A_3; A_4; A_5; A_{23}; A_{24}	C_1; C_2; C_3; C_4; C_5; C_6; C_7; C_8; C_{22}; C_{33}; C_{36}

Threatened plant species distribution

Table 1.3: Distribution records of *B. zanguebarica*, *P. africana*, *W. salutaris* and *R. vendae* in the Vhembe Biosphere Reserve, countrywide and elsewhere. [Keys: -: None; R_1 = Raimondo et al. (2009); R_2 = Hahn (2002); R_3 = Tshisikhawe (2013); R_4 = Tiawoun et al. (2018); R_5 = Tiawoun

et al. (2019); R_{6} = Mwitari et al. (2013); R_{7} = Ndam and Marcelin (2004); R_{8} = Bellewang (2005); R_{9} = Cunningham and Mbenkum (1993); R_{10} = Gyau et al. (2012); R_{11} = Nicosia et al. (2020); R_{12} = Palgrave et al. (2007); R_{13} = Opio et al. (2017); R_{14} = Senkoro et al. (2019); R_{15} = Timberlake et al. (2016); R_{16} = Timberlake, et al. (2009); R_{17} = Tolessa (2019); R_{18} = Bandeira et al. (2001); R_{19} = Bruschi et al. (2011); R_{20} = Conde et al. (2014); R_{21} = Singo (2007); R_{22} = Maroyi (2013b); R_{23} = Maroyi (2012); R_{24} = Augustino et al. (2011); R_{25} = Brown (2013); R_{26} = Chidhakwa (2003); R_{27} = Chhabara et al. (1990); R_{28} = Clarke and Dickinson (1995); R_{29} = Clark and Appleton (1997); R_{30} = Neimark (2010); R_{31} = Mugula et al. (2010); R_{32} = Osmaston (1968); R_{33} = Veeman et al. (2014); R_{34} = Dludlu et al. (2017); R_{35} = von Staden (2008)].

Plant name	**Recorded area of distribution in the Vhembe Biosphere Reserve, Limpopo Province**			**Recorded province of distribution countrywide**			**Recorded countries of distribution**	**Reference**
	Name	**Coordinates of location available**		**Name**	**Coordinates of location available**			
B. zanguebarica	Thengwe Village	Yes	Range from: -22° 24′ 0.0" and -23° 36′ 0.0" S to 29° 12′ 0.0" and 31° 12′ 0.0" E	-	No	-	Tanzania; Kenya; Mozambique; Uganda; Zimbabwe and Malawi	R_{1}; R_{3}; R_{4}; R_{5}; R_{11}; R_{12}; R_{15}; R_{16}; R_{19}; R_{20}; R_{21}; R_{26}; R_{27}; R_{28} and R_{32}

P. africana	Soutpansberg	No	-	Eastern Cape, Gauteng, KwaZulu-Natal, Mpumalanga and North-West Province	No	-	Madagascar; Tanzania; Uganda; Kenya; Cameroon; Ethopia and Mozambique	R_1; R_6; R_7; R_8; R_9; R_{10}; R_{17}; R_{18}; R_{30} and R_{31};
R. vendae	Makuleke Sandy Bushveld and Thengwe	No	-	-	No	-	-	R_1; R_2 and R_{35}
W. salutaris	Soutpansberg	No	-	North-eastern KwaZulu-Natal and Mpumalanga Province	No	-	Malawi; Mozambique; Eswatini; Zimbabwe; Tanzania; Uganda and Kenya	R_1; R_6; R_{13}; R_{14}; R_{22}; R_{23}; R_{24}; R_{25}; R_{26}; R_{29}; R_{33} and R_{34}

Threatened plant species' population statuses

Scientific evidence shows that the population size of many threatened plant species worldwide, declined, with an increase in extinction threats (Thogmartin et al., 2017; Naidoo et al., 2017; Barik et al., 2018; Stévart et al., 2019;). This was also supported by Tshisikhawe (2013), and Fenu et al. (2016) who emphasizes that threatened plant's population growth increases, with an increase in conservation efforts. Therefore, information about threatened plant's population size play a significant role in the assessment of individual species' conservation status (Epstein et al., 2016; McGowan et al., 2017). Table 2.4, is the review of population size records of utilized threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa.

Table 2.4: Population status of adult threatened plant species in the Vhembe Biosphere Reserve (Key: - = No local record)

Plant species	Updated national record (SANBI, 2020)	Local record
B. zanguebarica	25 individuals per hectare in 1997 (Williams and Raimondo, 2008)	80 individuals (Tiawoun, 2019, Tiawoun et al., 2019)
P. africana	57 individuals (Williams et al., 2008a)	-
R. vendae	Unknown (von Staden, 2008)	-
W. salutaris	Unknown (Williams et al., 2008b)	-

The fact that utilization and conservation of biological resources goes hand in hand, and are inextricable was also endorsed by the definition of biosphere reserve itself, international treaty on Plant Genetic Resource for Food and Agriculture, the United Nations Charter on Convention for Biological Diversity and the Section 24 of the Chapter 2: Bill of Rights of the Constitution of the Republic of South Africa. The current review revealed that scientific knowledge could not be the only knowledge to grant to grant amicable solutions about threatened plant species conservation. But, integrating scientific and indigenous knowledge systems in the conservation agenda could possibly grant sustainable future about threatened plant species in South African biosphere reserve and elsewhere. However, this review suggested the burning need to study indigenous knowledge pertaining conservation and utilization of natural resource in South African biosphere reserves, including the Vhembe in order to reduce the inherent gap of knowledge about biodiversity value for human development. Furthermore, for the first time this review summarizes information about utilized threatened plant species and their conservation status in the Limpopo Province as well as, the Vhembe Biosphere Reserve. Moreover, for the first time, the current review also summarizes detailed information about threatened plant species distribution, coordinates of locations and population status in the Vhembe Biosphere Reserve, countrywide and elsewhere.

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CHAPTER THREE

STUDY DESIGN AND METHODOLOGY

Chapter Three: Study design and methodology

Description of the study site

This study was undertaken in the Soutpansberg region of the Vhembe Biosphere Reserve, in the Limpopo Province, South Africa and its coordinate of location lies from 22º03´00" to 23º00´00" South latitude and 29º15´00" to 30º30´00" East longitude (Figure 3.1). The Vhembe Region of the Limpopo Province, South Africa was designated a biosphere reserve by the United Nations Education, Scientific and Cultural Organization (UNESCO) in 2009, and its initial periodic review of a 10 year life circle span from 2009 to 2019 (Evans, 2017; IUCN, 2021). However, currently the Vhembe Biosphere Reserve is on its second 10 year periodic review to be ended in 2030.

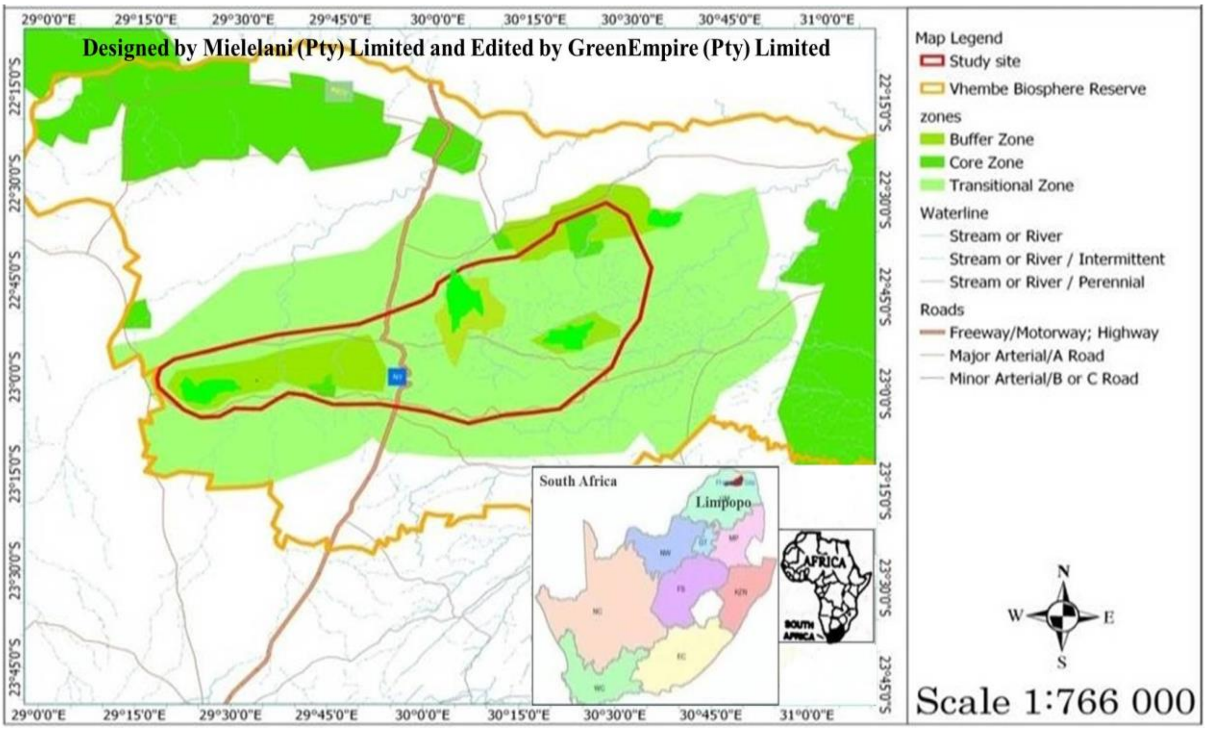

Figure 3.1: Locality map of the Vhembe Biosphere Reserve, Limpopo province, South Africa.

The Vhembe Biosphere Reserve is situated in the far-northern region of the Limpopo Province, in South Africa. Within the Vhembe Biosphere Reserve, there are five various local municipalities, including the Blouberg, Collins Chabane, Makhado, Musina and Thulamela. The Vhembe Biosphere Reserve is considered the second largest reverse of its nature in the

Republic of South Africa, and therefore, it covers the surface area of approximately 30 701 km^2 (Vhembe Biosphere Reserve, 2012; Evans, 2017). Its transitional zone covered surface area of about 22 526 km^2, followed by the core area (4 600 km^2) and buffer zone (3 575 km^2) (Steenkamp, 2015). The population size of people was approximately 1 393 950 in 2019 (Vhembe District Municipality, 2019), with the majority (97%) of dwellers residing in the rural areas (Vhembe Biosphere Reserve, 2012). More than 60% of the dwellers in the Vhembe Biosphere Reserve speak Tshivenḓa as their inborn language (Censes, 2011). The eastern site of the biosphere reserve is bordered by the Mokgalakwena River, with its southern border stretches from Blouberg-Mokgabeng and Soutpansberg Mountain Range through Luvuvhu River catchment, whereas, in the northern and eastern site, the reserve share its international borders with three neighbouring countries, including Botswana, Mozambique and Zimbabwe (Vhembe Biosphere Reserve, 2012).

Flora and fauna

The Vhembe Biosphere Reserve is composed of biomes, including savannah, grassland and some small patches forests (Rosmarin, 2018). A large portion of this reserve is dominated by the savannah, whereas, forest constitutes the smallest of all biomes within the reserve (Luseba and Tshisikhawe, 2013). The Vhembe Biosphere Reserve has rich biodiversity of flora and fauna (Hahn, 2006; Foord et al., 2015). This reserve is a home of several endemic plant species, including *Blepharis spinipes* Vollesen, *Delosperma zoutpansbergense* L.Bolus, *Aloe soutpansbergensis* I.Verd., *Encephalartos hirsutus* P.J.H.Hurter and *Combretum vendae* A.E.van Wyk var. glabratum N.Hahn (Hahn, 2016; Hahn, 2017), and various fauna species, including bats, Leopards, monkeys, spiders and many antelope species. Furthermore, Vhembe Biosphere Reserve is also a home of two threatened samango monkeys, namely, *Cercopithecus mitis* and *Cercopithecus albogularis* (Linden et al., 2015; Dalton et al., 2015). Van Wyk and Smith (2001), uttered that the Vhembe Biosphere Reserve is one of South African's most diverse region, whereas, Linden et al. (2014), emphasize that this region is an endemism hotspot. There are two recognized biodiversity and endemism center within the Vhembe Biosphere Reserve, which includes the Soutpansberg-Blouberg and Makgabeng Plateau (Mostert et al., 2008; Taylor et al., 2013). Kirchhof et al. (2010), recognizes some parts of the Vhembe Biosphere Reserve as an endemism harbor. Due to its uniqueness and floristic diversity, Hahn (2017), describes the Vhembe Region as a biodiversity refugia.

Climate and geology

(i) Climate

Climatic conditions in the Vhembe Biosphere Reserve are slightly of subtropical regions, ranging from mild-moist winter to warm-wet summer season (Gumbo et al., 2016; Edokpayi et al., 2016). The Vhembe Biosphere Reserve is climatically classified as arid and semi-arid (Nenwiini and Kabanda, 2013). The average annual rainfall in the Vhembe Biosphere Reserve measured using 203mm Rain Gauge, range from 300 to 820 mm (Mpandeli, 2014a) with the highest rainfall received in south-facing slope as compared to north-facing slope (Kephe et al., 2015). The average annual temperature for both summer and winter seasons range from 20 ºC to 30 ºC (Mzezewa and Rensburg, 2011). Despite the fact that the current seasonal rainfall status in the Vhembe Biosphere Reserve has declined by approximately 50 days as compared to some years back (Kabanda and Nenwiini, 2016), the highest rainfall is normally received during the summer season, which span from November to March, whereas the lowest rainfall is received during the winter season, span from May to August (Mpandeli, 2014a). The increasingly dry rainfall seasons in all parts of the Vhembe Biosphere Reserve seemed to be good indicators of climate change (Kabanda, 2017). The continuation of the dry rain season has negatively impacted the food security, water supply and threatened biodiversity across the entire reserve (Mpandeli, 2014b).

(ii) Geology and soil

The geological features in the Vhembe Biosphere Reserve have extended to the neighboring countries such as Zimbabwe, Botswana and Namibia (Chinoda et al., 2009). This includes features such as Kalahari Craton, Limpopo Belt, Archaean craton, Karoo systems and Bushveld Igneas complexity. The Limpopo belt is also considered as the zone of Granulite rocks (Brandl et al., 2006; Chinoda et al., 2009), whereas, the Kaapvaal Craton is known to be the separate part of the Limpopo Belt, separated by Palala Shear Belt in the southern site of the biosphere reserve (Barton et al., 2006; Hanh, 2011). The Limpopo Belt forms a typically good indication of previously occurred high-grade metamorphic terrane between Zimbabwe Craton and Kaapvaal Craton (Tsunogae and van Reenen, 2006). According to Buick et al. (2006), the Central Zone of the Limpopo Basin is formed of metasediment, metabasites and granitic gneisses. Some parts of the Vhembe Biosphere Reserve fall under the Limpopo River Basin, thereof, its sediments are composed of sandy stones, quartzite and alluvial sand that cover the bedrock at various depths (Nel and Nel, 2009). The Archean Kaapvaal is known to be covered under the flood basalt called Ventersdrop whereas, the Bushveld is widely known as the largest igneous intrusion in the world (Silver et al., 2006). Generally the soil type of the studied region includes the gravel sandy soil, sandy, loam and clay soils (Mzezewa and Van Rensburg, 2011; Joseph et al., 2019).

Materials and method

Ethical deliberation

(a) Ethical clearance

An application for ethical consideration was lodged with the University of Fort Hare's Ethics Committee, prior to the commencement of the current study. The University of Fort Hare reviewed the application, and then endorsed the current study with an Ethical Clearance Certificate (Ref. MAR0315RAM01). Both the University of Fort Hare and Faculty Code of Ethics were vigilantly considered during data collections. Participants who took part in the current study were acknowledged accordingly and as per the University of Fort Hare's Code of Ethics. During data collection, participant's autonomy was guaranteed to all the informants, and their autonomous rights were unambiguously explained using their inborn language. According to Bamigboye et al. (2017), local language simplifies communications between researchers and indigenous knowledge holders.

(b) Beneficiation

The current study provided participants, their communities and the management of the Vhembe Biosphere Reserve with baseline information required to prioritize the conservation of threatened plant species, while sustainably utilizing them.

(c) Intellectual property

Participants were informed that their participation in the current research project was voluntary and they could withdraw their participations at any time they wish to do so, and there should be no penalty for their acquittals. Participant's autonomous rights were also assured. Both verbal and written consent was entered into by both parties to ensure them that their knowledge and information could be only used for the research purpose. Participants were also assured that the findings of this research could not be commercialized, but used as baseline for developing holistic monitoring and management plan for threatened plant species in South African Biosphere Reserves, including the Vhembe Biosphere Reserve, in the Limpopo province. However, participants were also assured that if it happened that some findings in the current study, resulted in the production of any commercial product, people who shared such information could be acknowledged accordingly.

(d) Trade secrecy

The written non-disclosure consent of confidentiality stipulating all the confidential information was prepared and entered into the researcher and affected parties. However, this was done at the participant's request. Therefore, non-disclosure information never formed part of data analysis in the current study, but used as a guideline during the discussion of results.

Methodology

Justification of the methodology

Since the current study focused on assessing indigenous knowledge associated with threatened plant species utilization, conservation, categorizing these species according to their IUCN categories of threats, assessing their population size and their locational-distribution in the context of sociocultural, socioeconomic and socioecological significance, an integrated multi-disciplinary or triangulation research approach was appropriate. An integrated multi-disciplinary research approach is regarded as a rigorous research tool that interlinked qualitative and quantitative data together (Cassim, 2011). Hussein (2015) and Carter et al. (2014) argued that integrated multi-disciplinary research approach intensifies the accuracy and validity of the study, whereas, Onwuegbuzie and Leech (2005) indicated that, it examines all the datasets unambiguously. This strategic data gathering technique is consistent with both qualitative and quantitative research techniques (Palinkas et al., 2015).

Literature survey

The required literature was attained electronically from the databases included, Research-Gate, Science Direct, Google Scholar, Sabinet, MedPub, Wiley Online Library, Scopus, Springer and other Research Webs. Nevertheless, data about threatened plant's conservation status were attained from the IUCN's Red List of Threatened Species (Version 2019-2) and SANBI's Red List of South African Plants (Version 2017.1) databases. The International Plant Names Index (IPNI) database was also used to validate authorities on the botanical names of threatened plant species.

Ethnobotanical method

(i) Conceptualization

Since ethnobotany is an interdisciplinary science by definition (Jain, 1986; Prance, 2000; Medley and Kalibo, 2005; Heinrich et al., 2006; Pieroni and Privitera, 2014), its methodological design should involve disciplinary integration (Frei et al., 1998; de Albuquerque and Hurrell, 2010; Ross et al., 2014; Pascual and Orduna, 2020). An integrated participatory research approach focusing on shared learning, forging collaborative relations with participants, analyzing and validating the shared knowledge was designed, mainly to accumulate ethnobotanical data from dwellers within the studied region. This research approach was selected to allow the research stakeholders to trust one another and actively engaging each other at various levels (Bowen, 2015). Participatory research approach is considered to be a quick and effective way of acquiring data associated with indigenous knowledge systems (Chambers, 1994). To offset the elements of bias during the accumulation of ethnobotanical data, the research technique used in the current study was designed to accommodate core principles that interlinked participatory rural appraisal (PRA) and rapid rural appraisal (RRA) together. This includes, active learning, sharing of information and ideas (Chambers, 1994; Medley and Kalibo, 2005). Furthermore, the research techniques used in the current study integrate core principles that interconnect PRA and RRA, with conventional methods, including survey and questionnaires. Participatory rural appraisal herein defined as research technique used for accumulating ethnobotanical data from rural dwellers through active learning from them, involving them in the research process (either through dialogs, interviews or fieldwork), and empirical validating and analyzing their knowledge-information (Chambers, 1994; Robinson, 2002; Dovie, 2003; Jeruto et al., 2008; De Beer and Van Wyk, 2011; Singh et al., 2017). Rapid rural appraisal refers to research technique composed of systematics and semi-structured means of learning and acquiring data from rural people, while learning from them (Chambers, 1981; Conway and McCracken, 1990; Sturges and Chimseu, 1996; Takasaki et al., 2000). To prevent divergence from the study objectives, informant's participation in the current study was through passive and consultative means of participation. Passive participation refers to the participation whereby, research informants are being instructed or briefed about the major aspects of the study, including aims and objectives (Steinsbekk et al., 2013), whereas, consultative participation herein define as the participation, whereby, informants are being consulted about something and be able to provide the required answer (Smith et al., 2016; Samuel and Mqomboti, 2017).

(ii) Pilot survey

Ninety day pilot survey was conducted across the Vhembe Biosphere Reserve, prior to the commencement of data collection. The main purpose of the pilot survey was to inform traditional leaders about the intention to conduct the current study within the area of their jurisdictions, seeking permission to commence with data gathering, gaining participant's confidence, familiarizing them with the aim and objectives of this study and also testing for the reliability of the questionnaires. Since the current study was a participatory research, after obtaining the permission for the commencement with this study, traditional leaders were requested to voluntarily invite their people to take part in the pilot surveys, which were scheduled to occurred during the traditional gatherings called "*Khoro* or *Tshivhidzo tsha musanda"*, widely known as traditional indaba. To gain participant's confidence and also get known to participants, during pilot survey the researcher and all the assistance were firstly introduced by the traditional leaders, whom their people trusted. This was necessary since it has been a common understanding that mostly indigenous knowledge holders in the Vhembe Biosphere Reserve do not openly share their knowledge-information to a stranger (Ramarumo et al., 2019). Afterwards, the aim and objectives of the current study were explained to all the participants using their inborn language. During pilot survey, participants were also informed that their participation in the current study were voluntarily, their shared knowledge-information were only utilized for the research purpose, they have rights to acquit or withdraw their participations any time they wish to do so, and that there could be no consequences or punishment for their acquittals. Therefore, participants who agreed to take part in the current study were arbitrarily selected. A written informed consent was translated and presented to them using their inborn language, and they signed. Participants who were unable to read and write, gave their consent verbally so, whereas, those who read and write signed. Prior to the signing of informed consents, participants were informed that the face-to-face interview sessions could last for an hour and half minutes.

(iii) Participants' socio-demographic information

The total number of 203 participants took part in the current study, including laypeople (41.3%), traditional health practitioners (23.8%), farmers (9.9%), the escorts for traditional health practitioners (16.2%), hunters (5.2%) and environmentalists (3.5%) (Figure 3.2).

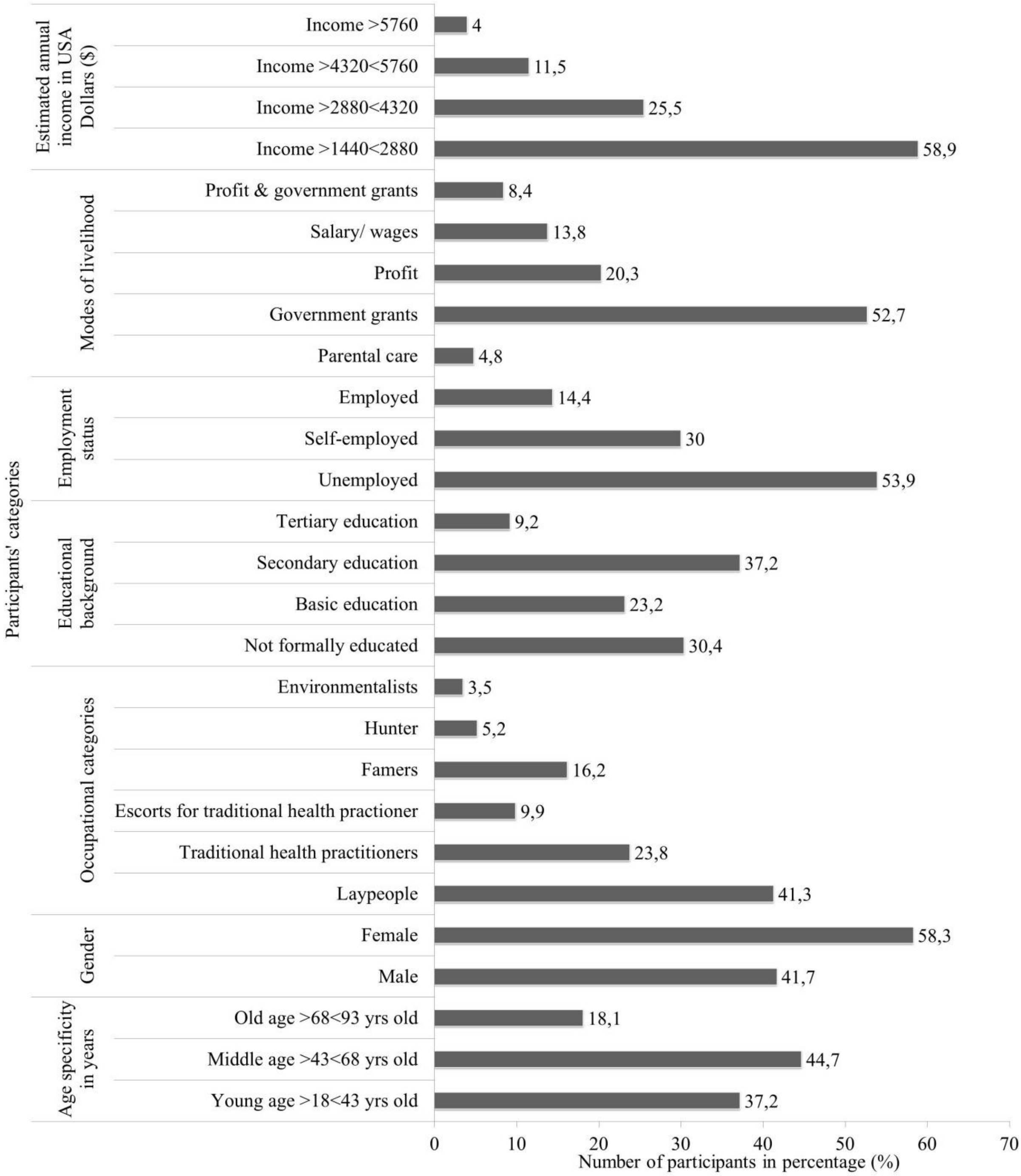

Figure 3.2: Participants' socio-demographic information

Although the Soutpansberg has been labelled as one of special economic zones in South Africa, due to the availability of its underground coal reserves (Department of Trade and Industry, 2017), its economic status still explicitly resembles poor reforms, with 90.8% of participants without tertiary educational qualifications. The unemployment rate > 53.9%, with the majority of people (57.5%) rely upon the government grants and parental support for livelihood and therefore, 58.9% of them seemed to earn an annual income of < US$ 2880 (Figure 3.2).

(iv) Data gathering and validations

The Ethnobotanical data collection was conducted over a period of 15 months, from August 2018 until October 2019. Information about useful threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province in South Africa was acquired through Participatory Rural Appraisal (PRA) using semi-structured questionnaires in an interview with the total number of 203 individual participants (Figure 3.2). The small sample size or number of participants chosen was motivated by the duration taken during the interview sessions (Flax et al., 2017).

Figure 3.3: Interviewing traditional health practitioner at her homestead

To avoid participation discreet and promote confidentiality amongst the participants, randomly selected participants were visited at their homestead and interviewed at the personal level as illustrated above (figure 3.3). Interviewing participants at the homestead was influenced due to the notion that state that the indigenous knowledge development is mostly rooted in households (Figure 3.3) (Speranza et al., 2010). During the interview sessions, participants were firstly reminded about the aim and objectives of the study, as well as, their participation rights, including the right to acquit participating in the current study anytime they feel to do so, with or without notice, and there could be no consequences for their acquittals. Although the interview sessions from one participant to another were scheduled to last for at least an hour and thirty minutes, all the participants were given the researcher's contact details, including the physical address, phone numbers and social-media contacts. This was necessary to afford them an equal opportunity to share their knowledge-information that could have been missed during face-to-face interview sessions. To maintain the validity, veracity and legitimacy of the participant's shared knowledge-information, the same questionnaires were administered to all the participants in the current study.

Population size and distribution of location survey

(i) Conceptualization

The current study was also intended to survey the population size and distribution of locations for various threatened plant species in the Vhembe Biosphere Reserve. Mostly threatened plant species are considered to be rare and scant to be found (Zietsman et al., 2008; Raimondo et al., 2009; Jimu and Ngoroyemoto, 2011; Szczecińska et al., 2016; Hahn, 2017; Xu et al., 2019). Therefore, literal counting of target individuals per taxon was a relevant method for surveying the population size and the location of distribution of these plant species. Literally counting herein, defined as an ecological research technique used to completely count the population size of species that occurred on a small scale (Fred and Brommer, 2003; Krauss et al., 2004; Bischoff et al., 2013; New Zealand Plant Conservation Network, 2021). Literature suggests that literally counting is an appropriate sampling technique for sampling species population size in a small area of occupancy (Keith, 2000; Severns, 2003; Reed, 2005; Leimu et al., 2006). Alldredge et al. (2008), emphasize that choosing a relevant sampling method is crucial in population ecology, since this may affect the accuracy of the findings, whereas, Kenkel et al. (1989), stipulated that sampling decision should remain consistent with the objective to be investigated. Although many population sampling methods rarely give the absolute count (Elphick, 2008), literally counting therefore reduce biasness, while improving the precision (Morgan, 1999; Tyre et al., 2003; Crone et al., 2011; Youatt, 2015), if the locations of where the target species distributed is known.

Although some threatened plant species were observed occurring in more than one location or having more than one subpopulation across the Vhembe Biosphere Reserve, literally counting was still a suitable research method to survey their population size, since all their subpopulations were found in a small area of occupancy. Only adult threatened plant individuals were counted per taxon, leaving other sample classes, including seedlings and juveniles untapped. This was influenced by the Version 3.1 of the IUCN's Red List Categories and Criteria, emphasizing that, only the matured and reproducing individuals of species should be considered for the conservation status assessment (IUCN, 2012). However, this study was never intended to assess the conservation status of any plant species across the Vhembe Biosphere Reserve. According to Version 3.1 of the IUCN's Red List Categories and Criteria, adult plant species are considered to be those species that either produces flowers, fruits or seeds (IUCN, 2012). Therefore, threatened plant individuals with, either flowers, fruits or seeds in every taxon were counted and consequently, their coordinates of location were marked using the Global Positioning System (GPS) Reader Application (Dead Duck Software, Version 4.0) on Samsung Galaxy J2 Core (Model number SM-J260F/DS). This was essentially, to avoid the re-count of individuals per taxon (Buckland et al., 2007; Tshisikhawe, 2012).

(ii) Field assessment survey

Literature studies suggest that indigenous people knew where to acquire natural resources that they need in their daily lives (Juanwen et al., 2012; Rusinga and Maposa, 2010; Ngara and Mangizvo, 2013; Araia and Chirwa, 2019). Moreover, Hahn (2017) assessed plant species of the Soutpansberg Region of the Vhembe Biosphere Reserve, and therefore, classified species with high conservation concern as rare and scant to be found. In this regard, it was necessary to undertake the field assessment survey together with participants who took part during ethnobotanical data gathering, since they knew where to find the target plant species. Field assessment surveys were undertaken prior to sampling of data associated with threatened plants population size and distribution of location, and also after ethnobotanical data sampling. The main aim of the field assessment surveys was to locate threatened plant's area of occupancy, their sub-populations within the studied region, initial identifications of the target plant species and also specimen collections.

(iii) Data sampling

After locating the areas where threatened plant species occurred across the Vhembe Biosphere Reserve, sampling of population size data begins in all their areas of occupancies. Data associated with locational distribution of threatened plant species was also recorded. During the population size survey, all the encountered adult individuals in very taxon, across all the identified areas of occupancy were literally counted, and subsequently marked using the GPS Reader Application (Dead Duck Software, Version 4.0), installed on the phone (Samsung Galaxy J2 Core, Model number SM-J260F/DS). This was to avoid the counting of individuals of certain plant species for more than once. Tshisikhawe (2012), emphasize the necessity of using the GPS Reader in population survey studies. Data about the locational distribution, including the geographic names of the areas where threatened plant species distributed and the coordinates of locations for every sampled taxon were also recorded using the GPS Reader. This kind of data is required for initiating the systematic monitoring and management of threatened plant species in the Vhembe Biosphere Reserve. Tulloch et al. (2014) and Lees et al. (2020), emphasizes the importance of locational distribution data in achieving systematic conservation planning.

(iv) Specimen collections

Presently the collection of plant materials in South Africa is regulated under the National Environmental Management, Biodiversity Act no. 10 of 2004 and the Bio-prospecting, Access and Benefit Sharing Regulations of 2008 (Raimondo, 2015). These regulations are also complemented by the National Biodiversity Framework, Threatened or Protected Species (TOPS) Regulations, Provincial Ordinances and Convention on International Trade in Endangered Species (CITES) Regulations (Crouch et al., 2008). Consequently, the collection of any plant materials is prohibited in South Africa, unless a relevant permit has been issued by an appropriate authority (Raimondo, 2015). Nevertheless, in the current study the specimen collection permits number: ZA/LP/92932 (Ref. CPM/20477/2018) and ZA/LP/100948 (Ref. CPM/30877/2019), were issued by the Limpopo Provincial Department of Economic Development, Environmental and Tourism (LEDET). Plant specimen collections occurred during the guided field assessment survey accompanied by participants who took part during ethnobotanical survey. During specimen collection, the target plant species were identified using their vernacular Venda names, and consequently, their botanical names were later authentically verified by the trained taxonomists. The collected specimens were then prepared (dried and mounted), organized (assigned the voucher numbers) and deposited in Botany Herbarium of the University of Venda.

Data analysis

All the gathered data were sorted according to their similarities, typed and stored in the spreadsheet program of the Microsoft Office Package. Qualitative data were organized into clusters and analyzed using percentages (%) in the form of graphs and tables. Convertible qualitative ethnobotanical data were converted into quantitative and analyzed statistically using ethnobotanical indices such as the use value (UV), relative frequency of citations (RFC), and fidelity level percentage (FL%) (Atyosi et al., 2019). According to Al-Qur'an (2009) and Umair et al. (2017), UV indicates the relative importance regarding the utilization of the cited plant species, and it is determined using the following formula:

$$UV_i = \frac{\sum U_i}{N}$$

Wherein, the UV is considered to be the use value of individual taxon, U, being the number of uses cited for that taxon and, therefore, N, represents the total number of recruits who cited the taxon (Phumthum et al., 2018; Shuaib et al., 2019). The relative frequency of citations (RFC), indicates local importance of every species within the studied region (Atyosi et al., 2019) and it is donated using the following formula:

$$RFC = \frac{FC}{N}(0 < RFC < 1),$$

Wherein, RFC, referred to the relative frequency of citations, FC, denotes the total number of the recruits who cited the use of individual taxon and, N, being the total number of all the recruits who took part in the current study (Ahmed et al., 2014; Kankara et al., 2015; Hussain et al., 2018). Fidelity level (FL) refers to the percentage of recruits who cited the use of certain threatened taxon within the studied region and it was determined using the formula adopted from Singh et al. (2019):

$$FL(\%) = \frac{N_P}{N} \times 100,$$

Wherein, the FL (%), denote fidelity level of percentage, N_P, represents the number of recruits who cited the certain threatened taxon for the particular uses, whereas, N, denote the total number of recruits who cited the uses of any threatened taxon (Andrade-Cetto et al., 2011; Ullah et al., 2014).

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CHAPTER FOUR

RESULTS

Chapter Four: Results

The inventory of useful threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

The present study revealed 13 useful threatened plant species in the Soutpansberg Site of the Vhembe Biosphere Reserve, Limpopo Province, South Africa. Only five species from the recorded threatened plants fall under the IUCN conservation status list (Year 2019), ranging from the IUCN Category, VU to EN. All the 13 recorded species contain the SANBI conservation status (Year 2017), including VU, EN, and CR (Figure 4.3 and Table 4.1). The reported species belong to 12 families, including Apocynaceae, Asparagaceae, Canellaceae, Dioscoreaceae, Fabaceae, Hyacinthaceae, Lauraceae, Ochnaceae, Proteaceae, Rosaceae, Zamiaceae, and Zingiberaceae. Family Lauraceae contains two tree species, whereas, other families are represented by a single species (Table 4.1). Moreover, family Lauraceae was only noticed in the Vonḓo site, which forms part of the Afromontane forest in the Soutpansberg (Table 4.2).

Table 4.1: An inventory of threatened plant diversity in the Soutpansberg Site of the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Family	Botanical names and voucher specimen number	Vernacular Venda names	Plant form	IUCN status	SANBI status	Socio-developmental values	Plant parts used	Same use citations	UV	RFC	FL (%)
Apocynaceae	*Huernia nouhuysii* I.Verd. (RAMLJ 021)	Tshiḓitshinzhi-tsha-Vhusendeka*	Succulent	–	VU	Birdlime-making	Latex	–	0.250	0.019	1.970
Asparagaceae	*Asparagus sekukuniensis* (Oberm.) Fellingham & N.L.Mey. (RAMLJ 013)	Lufhaladzamakole-lwa thavha	Cactus	EN	EN	Medicinal	Whole plant	A	0.077	0.064	6.404
Canellaceae	*Warburgia salutaris* (G.Bertol.) Chiov. (RAMLJ 014)	Mulanga	Tree	EN	EN	Medicinal	Bark, leaves and root	B_1, B_2 and B_3	0.0278	0.177	17.734
Dioscoreaceae	*Dioscorea sylvatica* Eckl. (RAMLJ 023)	Lurangatshiredzi*	Climber	VU	VU	Ethnoveterinary medicine	Bulb tuber	–	0.100	0.049	4.926

Fabaceae	*Rhynchosia vendae* C.H.Stirt. (RAMLJ 025)	Musivhamaṱo	Climber	–	VU	Medicinal and ornamentals	Whole plant	C	0.167	0.059	5.911
Hyacinthaceae	*Bowiea volubilis* Harv. *ex* Hook.f. subsp. *volubilis* (RAMLJ 015)	Nyalakhobvu/ Khobvumutovu	Climber	–	VU	Medicinal	Whole plant	D	0.077	0.064	6.404
Lauraceae	*Ocotea kenyensis* (Chiov.) Robyns & R.Wilczek (RAMLJ 026)	Mulafhadali*	Tree	VU	VU	Medicinal and timber	Bark, root, and the leaves	E	0.067	0.059	5.911
Lauraceae	*Ocotea bullata* (Burch.) Baill. (RAMLJ 033)	Mulafhadali*	Tree	–	EN	Medicinal	Back and leaves	F_1 and F_2	0.063	0.079	7.882
Ochnaceae	*Brackenridgea zanguebarica* Oliv. (RAMLJ 027)	Muṱavhatsindi	Tree	–	CR	Medicinal	Barks and root	D, G_1, G_2 and G_3	0.024	0.202	20.197

Proteaceae	*Protea laetans* L.E.Davidson (RAMLJ 029)	Muphuphadzingu*	Shrub	VU	VU	Medicinal	Fruit and root	–	0.091	0.053	5.419
Rosaceae	*Prunus africana* (Hook.f.) Kalkman (RAMLJ 031)	Mulalamaanga	Tree	–	VU	Medicinal and timber	Bark and stem	D	0.182	0.053	5.419
Zamiaceae	*Encephalartos hirsutus* P.J.H.Hurter (RAMLJ 032)	Muvayambilana*	Cycad	–	CR	Medicinal and ornamentals	Whole plant	–	0.200	0.049	4.926
Zingiberaceae	*Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt (RAMLJ 030)	Dzhinzhadaka*	Herb	–	CR	Medicinal and ornamental	Whole plant	H_1, H_2 and H_3	0.143	0.069	6.897

Key notes: *, Varnecular Venda name that had never been recorded before; A, Ramarumo et al., 2019a; B_1, Maroyi, 2014; B_2, Dludlu et al., 2017; B_3, Kunene and Masarirambi, 2018; C, Magwede et al., 2019; D, Ramarumo et al., 2019b; E, Williams et al., 2013; F_1, Ogundajo et al., 2018; F_2, Ngubeni et al., 2017; G_1, Tiawoun et al., 2019; G_2, Tiawoun et al., 2018; G_3, Constant and Tshisikhawe, 2018; H_1, Ullah et al., 2014; H_2, Fouche et al., 2013 and H_3, Van Wyk, 2015). A, Ramarumo et al., 2019a;B_1, Maroyi, 2014; B_2, Dludlu et al., 2017; B_3, Kunene and Masarirambi, 2018; C, Magwede et al., 2019; D, Ramarumo et al., 2019b; E, Williams et al., 2013; F_1, Ogundajo et al., 2018; F_2, Ngubeni et al., 2017; G_1, Tiawoun et al., 2019; G_2, Tiawoun et al., 2018; G_3, Constant and Tshisikhawe, 2018; H_1, Ullah et al., 2014; H_2, Fouche et al., 2013 and H_3, Van Wyk, 2015). A, Ramarumo et al., 2019a;B_1, Maroyi, 2014; B_2, Dludlu et al., 2017; B_3, Kunene and Masarirambi, 2018; C, Magwede et al., 2019;

D, Ramarumo et al., 2019b; E, Williams et al., 2013; F_1, Ogundajo et al., 2018; F_2, Ngubeni et al., 2017; G_1, Tiawoun et al., 2019; G_2, Tiawoun et al., 2018; G_3, Constant and Tshisikhawe, 2018; H_1, Ullah et al., 2014; H_2, Fouche et al., 2013 and H_3, Van Wyk, 2015).

Table 4.2: Threatened plant species distribution, locations and observed threats across the Soutpansberg Region of the Vhembe Biosphere Reserve, Limpopo Province, South Africa.

Plant species	**Plant species location**			**Number of observed locations within the studied region**	**Observed threats**
	Location	**Coordinates of location**			
		Latitudes	**Longitudes**		
Asparagus sekukuniensis	Muruṅwa	22º58′59.052" S	30º10′28.477" E	1	Habitat transformation due to human-settlement and recurring high intensity fire man-made fire
Bowiea volubilis subsp. *volubilis*	Mauluma; Tshiṱavha, Matshavhawe and	22º56′10.293" S; 22º57′57.953" S; 22º58′26.17 " S and	30º9′32.992" E; 30º11′27.225" E; 30º7′9.699" E and 30º10′59.016" E	4	Over-harvesting, invasion by alien plant species

	Vuvha	22º59′34.091 3" S			
Brackenridgea zanguebarica	Thengwe	22º40′22.325" S	30º34′22.659" E	1	Over-exploitation due high subsistence and commercial demand
Dioscorea sylvatica.	Tshifhire, Muruṅwa and Tshamaṱangwana	23º0′19.901" S; 22º59′26.002" S and 22º58′19.423" S	30º7′52.852" E; 30º9′24.623" E and 30º18′23.864" E	3	Habitat transformation due to new human-settlement development, invasion by alien plant species and over-harvesting
Encephalartos	Muruṅwa and Vonḓo ḽa Thavha	22º59′46.154" S and 22º56′14.813" S	30º9′25.974" E and 30º21′8.15" E	2	Over-exploitation due to high commercial demand at both local and international markets
Huernia nouhuysii	ḒoliḒoli	22º42′15.742" S	30º10′26.554" E	1	Recurring drought, invasion by alien plant species and habitat transformation due to new

					human-settlement development
Ocotea bullata	Tshaṋowa Mountain, Thathe Vonḓo	22º56′18.719" S	30º21′8.373" E	1	Habitat fragmentation due to pine plantation
Ocotea kenyensis	Thethe Vonḓo Holy forest, and Tshamatingwane	22º53′6.374" S and 22º58′19.844" S	30º18′41.363" E and 30º18′15.879" E	2	Habitat fragmentation due to pine plantation
Protea laetans	Muruṅwa Mutshedzi and Muruṅwa Maramboni	22º58′14.937" S and 22º59′13.65" S	30º18′20.503" E and 30º8′59.46" E	2	Habitat transformation due to new human-settlement development, recurring high intensity man-made fire
Prunus africana	Khalavha, Tshiṱangani site and Thathe Vondo, Tshaṋowa	22º55′5.956" S and 22º55′32.456 " S	30º18′24.894" E and 30º20′46.883" E	2	Habitat fragmentation due to pine plantation

	Mountain Valley				
Rhynchosia vendae	Makonde and Ha-Maelula	22º47′19.536" S and 22º59′9.146" S	30º33′47.509" E and 30º8′51.234" E	2	Invasion by alien plant species and habitat transformation due to new human-settlement development
Siphonochilus aethiopicus	Thathe Vondo, Tshamaṱingwane	22º58′11.676" S	30º18′17.197" E	1	Over-exploitation
Warburgia salutaris	Ha-Matsa	22º50′36.922" S	29º59′50.107" E	1	Over-exploitation due to commercial demand in local market

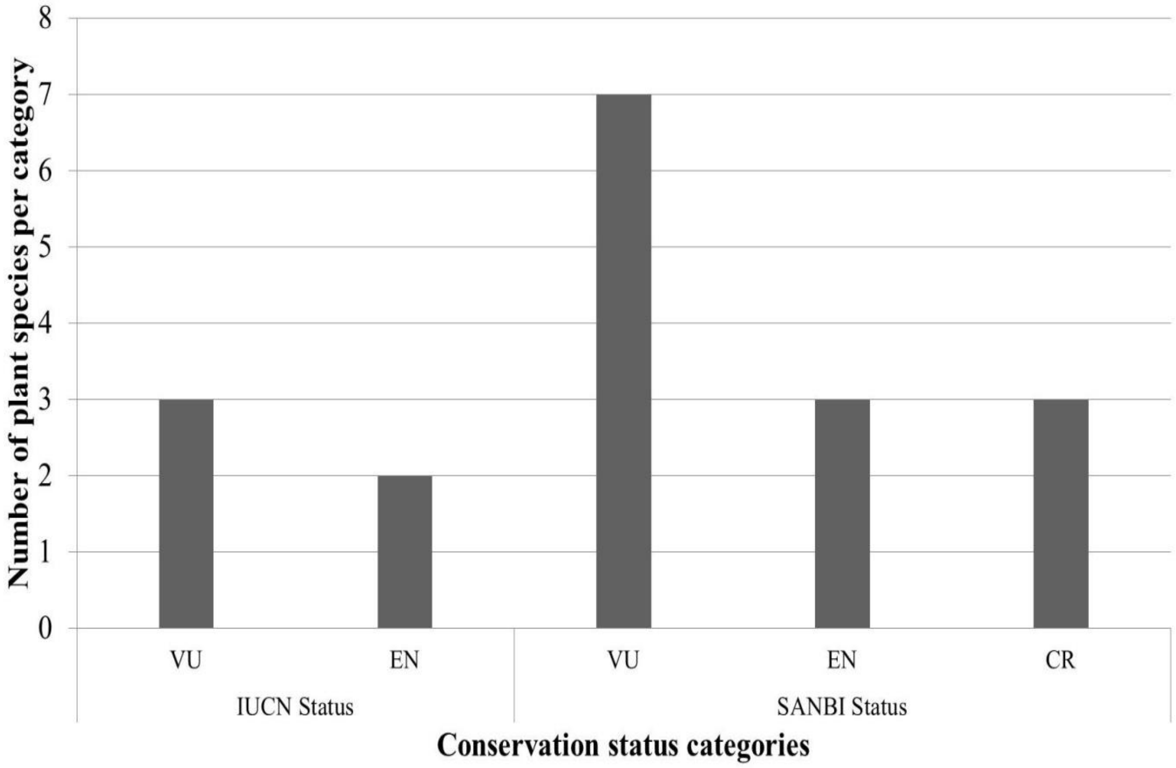

Figure 4.1: Number of international and national Red Listed threatened plant diversity.

The frequently cited useful threatened plant species with UV > 0.024, RFC > 0.059 and FL > 5.911% included *A. sekukuniensis*, *B. volubilis* subsp. *volubilis*, *B. zanguebarica*, *O. bullata*, *R. vendae*, *S. aethiopicus*, and *W. salutaris* (Table 4.1). *W. salutaris* and *B. zanguebarica* are frequently utilized by local people within the studied region and their FL values range from 17.734% to 20.197%. Results of the current study showed that local people utilize *W. salutaris* and *B. zanguebarica* for medicinal purposes only (Table 4.1).

Local people within the studied region were found utilizing various threatened plant species for various purposes, depending on their growth habits and plant part used (Table 4.1 and Figure 4.2). This includes utilizing those species for medicinal purposes (46.0%), medicinal and ornamentals (23.0%), medicinal and timber (15.0%), ethnoveterinary medicine (8.0%), as well as birdlime-making and ornamentals (8.0%) (Figure 4.2A). Trees (38.0%) and climbers (23.0%), were the most preferred plant form, whereas, the frequently utilized part was whole plant (38.0%), followed by the combination of bark, leaves, and root (15.0%) (Figure 4.2B and C).

Distribution and population

More than 53.0% of the recorded useful threatened plant species are distributed in one location across the studied region. The results of the present study delineate that about 47.0% of the recorded useful threatened plant species was distributed in the remote areas of the Thathe Vonḓo and its surroundings. Table 4.2 shows that threatened plant species within the studied region are mostly threatened due to various threats regimes, including, habitat transformation, habitat fragmentation, over-harvesting, and invasion.

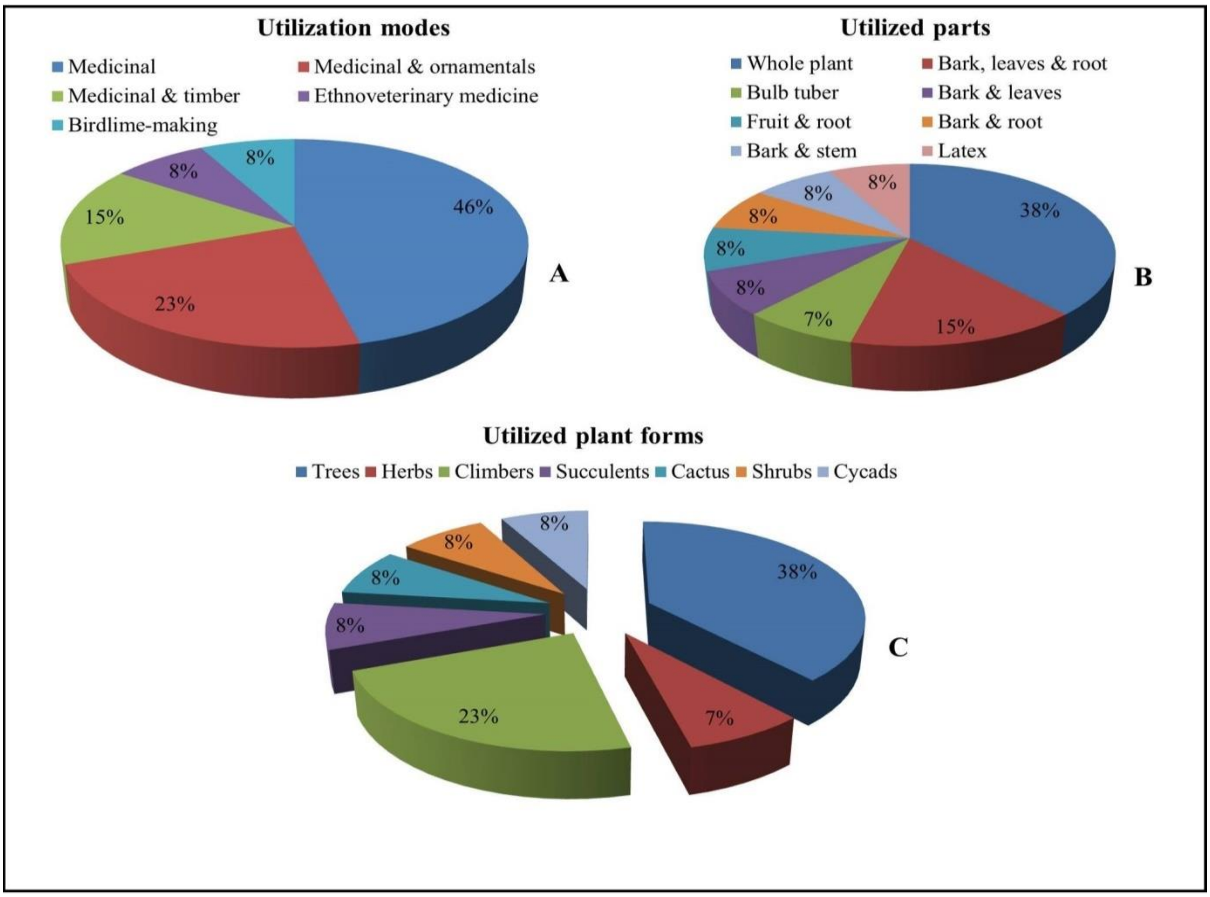

Figure 4.2: Utilization of threatened plant biodiversity.

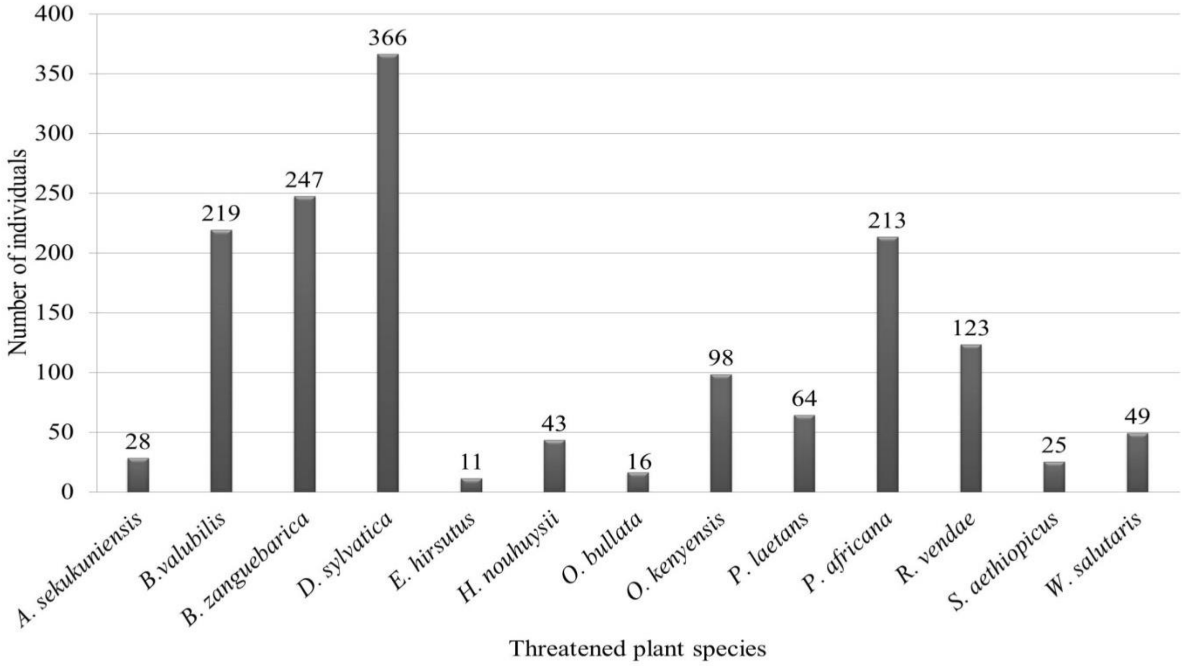

Figure 4.3: Adult threatened plants within the Vhembe Biosphere Reserve.

The population size of *D. sylvatica* were found to be over 300 individuals with various distributional ranges as compared to its counterparts (Figure 4.3 and Table 4.2). Presently the distribution range of *D. sylvatica* in the studied region is restricted to three small remote areas called Tshifhire, Muruṅwa, and Tshamaṱangwana (Table 4.2). The conservation status of this species is only recognized at national level (Figure 4.1 and Table 4.1). The results of this study show that threatened plant species consist of a population size less than 100 adult individuals constituting an overall of 61.54% (Figure 4.3). Among the threatened plant species are *P. laetans*, *O. kenyensis*, *O. bullata*, *A. sekukuniensis*. *W. salutaris*, *H. nouhuysii*, *E. hirsutus* and *S. aethiopicus* (Figure 4.3).

Therapeutic uses, preparation, and administrative techniques of *Warburgia salutaris* (G. Bertol.) Chiov., *Asparagus sekukuniensis* (Oberm.) Fellingham & N.L.Mey. and *Bowiea volubilis* Harv. *ex* Hook.f. subsp. *Volubilis* in the Vhembe Biosphere Reserve, Limpopo Province South Africa

***Warburgia salutaris* (G.Bertol.) Chiov.**

Table 1, delineates the therapeutic uses of *W. salutaris* in Nzhelele Region. The fidelity level (FL) of *W. salutaris* ranged from 6.3 to 17.7% (Table 4.3). *Warburgia salutaris* is used in the treatment of more than one illness in the Vhembe Biosphere Reserve (Table 4.3). The results showed that two-third (69.4%) of *W. salutaris* therapeutic preparations involved combining with other plants (Table 4.3). The mixing of *W. salutaris* with other herbal medicines only occurred when treating toothache (FL=17.7%), bilharzia (FL=15.3%), womb cleaning after recurring miscarriages (FL=13.8%), ear-ache (FL=8.8%), asthma (FL=7.5%) and colds (FL=6.5%) but, non-fusion occurred when treating, period-pains (FL=12.5%), spinal cord-pains (FL=10.0%) and genital sores (FL=8.1%) (Table 4.3). The fusion of *W. salutaris* with other plants emphasizes the wealth of ethnopharmacological knowledge within the Soutpansberg Region.

Table 4.3: Therapeutic uses of *Warburgia salutaris*, preparatory and administrative modes [FL (%) = Fidelity level percentage]

Therapeutic uses of *Warburgia salutaris*	**Preparatory modes**	**Administration modes**	**Parts used**	**FL (%)**
Toothache (in human beings and dogs) (Maroyi, 2013)	Fusion of fresh barks with root of *Eriosema psoraleoides* (Lam.) G.Don are soaked in warm water for about 24 hours	Infusion on the cup is used as mouth-wash three-times per day (morning, afternoon and evening) (each tumbler per wash) for 7 days	Barks	17.7
Bilharzia	Mixture of bark with leaves of *Aloe marlothii* A.Berger subsp. *marlothii* and barks of *Pterocarpus angolensis* DC., *Peltophorum africanum* Sond., and *Senna petersiana* (Bolle) Lock, are boiled in water for an hour	Decoction on the cup is orally taken, three-times per day for 4 weeks (in the morning, afternoon and evening)	Barks	15.3

Womb cleaning (after a miscarriage and enhancing the chances of getting impregnated again)	Mixture of fresh barks with roots of *Cucumis africanus* L.f., are soaked in warm water 24 hours	Infusion on the cup is taken orally once per day for three weeks	Barks	13.8
Period pains	Either fresh or dried roots are boiled with water for 45 minutes	Decoction on the cup is taken orally once per day, three days towards the menstruation date	Root	12.5
Spinal cord pains (Maroyi, 2013)	Dried root is grounded into a fine powder	A Razor-blade is used to make small cuts in the patient's skin along the spinal cord to allow some blood to come out and medication is then applied into the bleeding parts to enter the blood stream	Root	10.0
Ear-ache	Infusion of fresh leaves with those of *Hibiscus cannabinus* L., are crushed and squeezed to produce a liquid extracts	One drop of the extracted liquid is poured into painful ear twice per day	Leaves	8.8
Genital sore	Fresh leaves are crushed and squeezed to produce liquid	The solution is used to wash the genital sores	Leaves	8.1

	extracts and about 10 drops of the extracts poured into a 1 liter bottle of warm water, containing 1 spoon of dissolved salt	twice per day (in the morning and evening)		
Asthma	Mixture of dried leaves with those of *Helichrysum kraussii* Sch.Bip., are grounded into powder	The powdered mixture is smoked as cigarette to heal asthma	Leaves	7.5
Colds (Rabe and Van Staden, 2000; Maroyi, 2013)	Mixture of dried barks and those of *Zanthoxylum capense* (Thunb.) Harv., are boiled in water for 30 minutes	Decoction is orally taken to cure or vaccinate colds	Barks	6.3

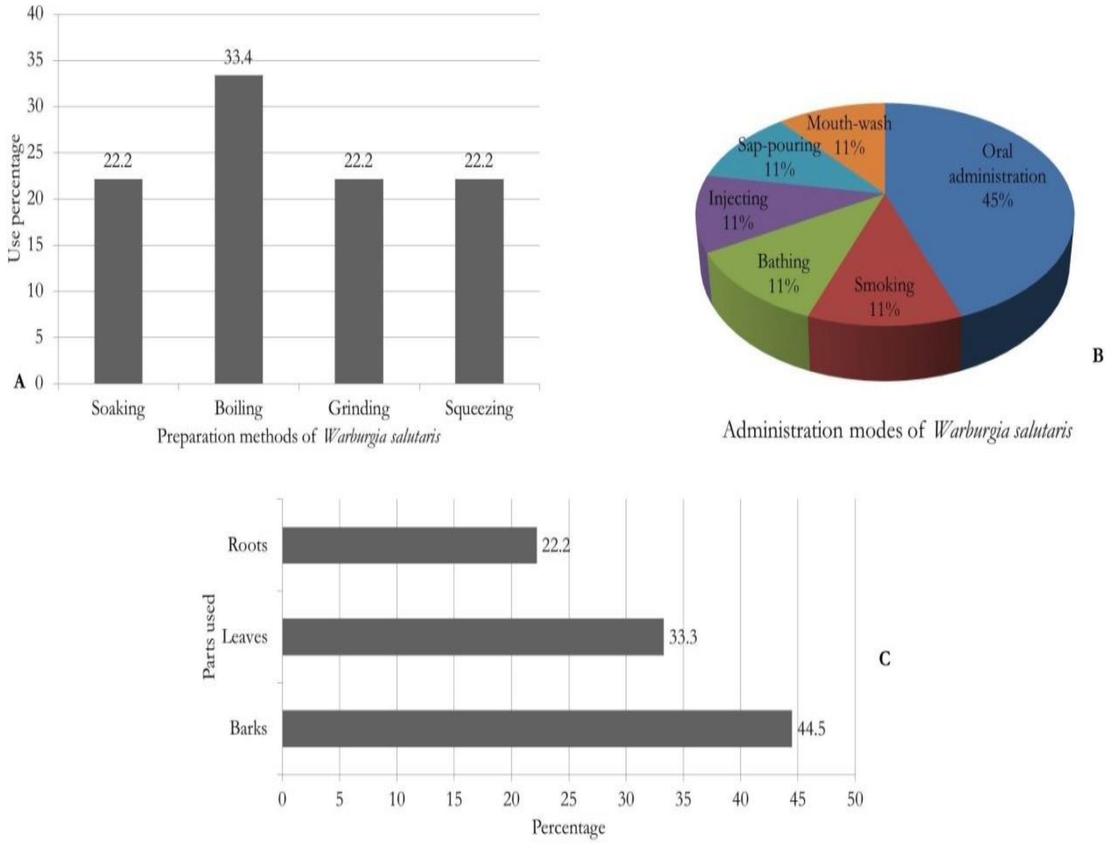

Figure 4.4: The preparation method and administration processes of *Warburgia salutaris* therapeutics.

The results showed that there are variations among pharmacological preparations and administration of *W. salutaris* (Figure 4.4A and 4.4B). Four preparation methods and six administration procedures, were being used across the study areas (Figure 4.4 and Table 4.3). Boiling (33.4%), was the most cited preparation method, followed by soaking (22.2%), grinding (22.2%) and squeezing (22.2%) (Figure 4.4A). Among the recorded administration processes of *W. salutaris* against illnesses, oral (45%) was the most frequent administration mode, whereas, smoking (11%), bathing (11%), injection (11%), sap-pouring (11%) and mouthwash were equally used (Figure 4.4B). Nevertheless, participants have reported that the duration period and dosage of *W. salutaris* varies from one patient to another and the nature of the illness (Table 1). Bark (44.55), was the most frequently used part of *W. salutaris*, followed by the leaves (33.3%) and roots (22.2%) (Figure 4.4C).

***Asparagus sekukuniensis* (Oberm.) Fellingham & N.L.Mey.**

Table 4.4 shows the therapeutic uses, preparation techniques, and administration procedures of *A. sekukuniensis* by the Vhavenḓa people in the Soutpansberg Region, Vhembe Biosphere

Reserve, Limpopo province, South Africa. A total of six ethnomedicinal uses of *A. sekukuniensis* were recorded in the current study. The Fidelity Level (%) of the six recorded *A. sekukuniensis* uses ranged from 8.0% to 24.8% (Table 4.4). More than 64.8% of all the participants in the current study communally utilize *A. sekukuniensis* for child health care-related ailments (Table 4.4). Traditional health practitioners across the study sites have stated that they utilize *A. sekukuniensis* for therapeutic purposes against a variety of ailments, including enhancement of fontanelle closure in infants (FL=24.8%), convulsions in infants (FL=22.4%), vaccinating epilepsy in infants (FL=17.6%), treating the unhealed or cancer-related wounds (FL=15.2%), genital wounds (FL=12.0%), as well as boils treatment in both human beings and livestock (FL=8.0%) (Table 4.4). The *A. sekukuniensis* plant parts utilized included roots (50%) and whole plant (50%) (Table 4.4).

Table 4.4: Therapeutic uses, preparation and administrative modes of *Asparagus sekukuniensis* [Key: FL (%) = Fidelity level percentage]

Therapeutic uses	Used part	Preparatory modes	Administration modes	FL (%)	Same use citations
Enhancement of fontanelle closure in the infants	Root or rhizome	Burned black ashes are ground into fine powder and then mixed with saturated oil	Small cuts are made on the skin around the fontanelle part using a razor-blade and then medication is administered to the bleeding area	24.8	None
Convulsions in the infants	Whole plant	The grounded powder is mixed with a fine powder made from barks of *Maerua angolensis* DC. subsp. *angolensis*	Small cuts are made around or on different body parts of the newly born baby using a razor blade to allow blood to come out and then the medication is administered into the bleeding area to allow it to enter into the blood stream. Afterwards, the same mixture of powder is then poured into a heated clay pot without water while covering the patient with a blanket to contain the produced smoke	22.4	Mabogo (1990)
Vaccination of epilepsy	Whole	Burnt to produce smoke and	The naked newly born baby carried by the herbal practitioner is moved around the produced	17.6	None

in the infants	plant	ashes	smoke three times per day (morning, afternoon and evening) for the period of a week. The burned ashes are then mixed with the urine of the rock rabbit ("Ṱhulo") and then taken orally twice per day until the newly born baby is two years old. The mixture of ashes and urine of rock rabbit is called "*Muuluso*"		
Unhealed or cancer-related wounds	Root or rhizome	A decoction of fresh root, dried root is ground into a fine powder and mixed with a powder made from the barks of *Ozoroa reticulata* (Baker f.) R.Fern. & A. Fern	A decoction of fresh roots taken orally whereas, a mixture of powders is administered into the unhealed wounded body part	15.2	None
Genital wounds	Root or rhizome	The dried root is ground into a fine powder and then mixed with saturated oil	Administered to the wounding area	12.0	None
Boil in both humans and	Whole	Fresh materials are boiled to	Steam is applied around the area where boil	8.0	None

live stocks	plant	produce steam	occurs to soften it so that it gets healed		

Bowiea volubilis* Harv. *ex* Hook.f. subsp. *Volubilis

The results of the present study showed that *B. volubilis* is utilized by local traditional healers as herbal medicine against an assortment of assorted diseases (Table 4.5). More than 80% of traditional healers within the study sites to mix *B. volubilis* with other herbal remedies while using decoction as a major preparation method (Table 4.5). The total of five therapeutic uses associated with *B. volubilis* were recorded in the current study and their fidelity level (FL) ranged from 15.8 to 24.8%. The recorded therapeutic uses of the plant species included for the treatment of rash and skin smoothening (FL=24.8%), anthelmintics in infants (FL=23.3%), liver infections (FL=18.8%), pelvic pains in women (FL=17.3%) and jaundice in infants (FL=15.8%) (Table 4.5).

Table 4.5: Therapeutic uses of *Bowiea volubilis*, preparatory and administrative modes [Key note: FL (%) = Fidelity level percentage]

Therapeutic uses	Preparatory modes	Administration modes	Used parts	FL (%)	Same use citations
Rash and skin smoothening	Chopped fresh bulb is crushed and squeezed to produce the liquid extracts	Five to ten drops of liquid extract are applied on skin sore as body lotion twice per day for five days	Bulb	24.8	(Jäger and, van Staden, 2000; Philander, 2011; Masondo et al., 2013)

Infant anthelmintic	Decoction of boiled and chopped pieces of fresh bulb and fresh root of *Athrixia phylicoides* DC.	Two spoons of decoction are taken orally, three times per day for one month	Bulb	23.3	None
Liver infections	Decoction of boiled fresh parts (whole plant) together with fresh roots of *Momordica boivinii* Baill, *Momordica balsamina* L., *Momordica cardiospermoides* Klotzsch, *Momordica foetida* Schumach, *Momordica repens* Bremek.	Decoction on the cup is taken orally, three times per day for two months	Whole plant	18.8	None
Pelvic pains in women	Decoction of boiled and chopped fresh bulb and *Artabotrys monteiroae* Oliv., is mixed with maize meal to make soft porridge	Taken as soft porridge twice per day, for one week	Bulb	17.3	(Philander, 2011; Williams et al., 2013)

Infant jaundice	Decoction of boiled fresh parts (whole plant) and fresh rhizome of *Rhus lancea* (L.f.) F.A. Barkely as well as *Kniphofia crassifolia* Barker	Decoction on the spoon is taken orally, three-times per days for two weeks	Whole plant	15.8	None

Birdlime-making plant species: Techniques, synthetic procedures, uses and complementary contribution to human development in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

A total number of 12 birdlime-making plants belonging to 6 families were recorded, including the threatened *H. nouhuysii*, which is categorized under Vulnerable species in South Africa (Table 4.6). Amongst the recorded families, Loranthaceae and Ephorbiaceae were the most frequently utilized families. Among the recorded species, six of them were reported for their uses in birdlime-making for the first time and this included *E. pulvinata* (17.2%), followed by *T. forbesii* (8%), *T. rubromarginatus* (7.2%), *E. ngamicum* (7.2%), *E. magalismon-tanum* (3.6%), *H. nouhuysii* (2.0%), and *E. tirucalli* (0.8%) (Table 4.6). Only three plant parts were utilized for birdlime-making in the study area, and therefore, milky latex has been the regular preferred plant part, followed by fruit and root bark (Table 4.6).

Table 4.6: Birdlime-making plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Plant name	**Used part**	**Informant's consensus (%)**	**Cited before**
Huernia nouhuysii I.Verd. (Apocynaceae)	Milky latex	2.0	No
Landolphia kirkii Dyer ex Hook.f. (Celastraceae)	Milky latex and fruit	12.0	Yes: Mabogo (1990); Parkia et al. (2003); Constant and Tshisikhawe (2018); Magwede et al. (2018)
Maytenus peduncularis (Sond.) Loes (Celastraceae)	Root bark	23.6	Yes: Mabogo (1990); Magwede et al. (2018)
Euphorbia pulvinata	Milky latex	17.2	No

Marloth (Euphorbiaceae)			
Synadenium cupulare (Bioss.) L.C. Wheeler (Euphorbiaceae)	Milky latex	3.6	Yes: Hargreaves (1978); Pakia et al. (2003)
Euphorbia tirucalli L. (Euphorbiaceae)	Milky latex	0.8	Yes: Mabogo (1990); Magwede et al. (2018)
Erianthemum dregei (Eckl. & Zeyh.) Tiegh (Loranthaceae)	Fruit	8.8	Yes: Hargreaves (1978); Mabogo (1990); Magwede et al. (2018)
Erianthemum ngamicum (Sprague) Danser (Loranthaceae)	Fruit	7.2	No
Tapinanthus forbesii (Sprague) Wiens (Loranthaceae)	Fruit	8.0	No
Tapinanthus rubromarginatus (Engl.) Danser (Loranthaceae)	Fruit	7.2	No
Ficus thonningii Blume (Moraceae)	Milky latex	6.0	Yes: Platt et al. (2012); Magwede et al. (2018)
Englerophytum	Milky latex	3.6	No

magalismontanum (Sond.) T.D.Penn. (Sapotaceae)			

Table 4.7 reports birdlime-making techniques and synthetic procedures in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. The results on the current study revealed three techniques that are used in the synthesis of birdlime across the Vhembe Biosphere Reserve. These techniques includes, crushing, (55.7%), air blowing (29.6%), and boiling (14.7%). It was found that local people of the study area uses several plant parts while synthesizing birdlime. This included the milky latex, fruit and root bark (Table 4.7). The latex extracted from *L. kirkii* stem seem to be an important component in the birdlime synthesis across the Vhembe Biosphere Reserve, and therefore, no birdlime could be considered complete without undergoing the strengthening technique called "*Mukumululo*" using such latex (Table 4.7). "*Mukumululo*" herein defined as a birdlime strengthening technique whereby sticky substances derived from plant material are mixed with latex extracted from the stem of *L. kirkii* to become complete birdlime.

Figure 4.5 illustrates the use of birdlime in roof waterproofing. Informants within the study area reported four complementary uses of birdlime which includes, bird hunting or trapping small birds (45.8%), adhesion (23.2%), and teeth cleaning (17.2%), as well as, roof-waterproofing (13.8%) (figure 4.5) (Table 4.8). In the Vhembe Region, birdlime seemed to be significantly contributing to various levels of human development, including nutritional values, human shelter development and repair, glue and paper sticker making, as well as, human health (Table 4.8).

Figure 4.5: Use of birdlime in roof waterproofing

Table 4.7: Birdlime-making techniques and synthetic procedures for its production in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Processing technique	**Plant part**	**Synthesis procedure**	**%**
Crushing	Fruit	The ripe fruit coat is crushed until it becomes sticky, and then washed using cool-water to discard some remaining cellulose pies. The sticky substance, undergo strengthening using a technique called "*Mukumululo*", whereby it is mixed with milky latex extracted from *L. kirkii* in order to become complete or strong birdlime	35.5
	Root bark	Root barks are crushed until it becomes sticky, and then washed using cool-water to discard some remaining bark pieces. The sticky substance, undergo strengthening using latex extracted from the stem of *L. kirkii*	20.2
Boiling	Milky latex	Milky latex, particularly those extracted from genus *Euphorbia* L., is boiled in open space since it is believed that if could cause some serious eye damage and skin irritations if boiled in close spaces. Starred while boiling for approximately 30 to 45 minutes, and then allowed to cool and become thick and sticky, before it undergo strengthening through mixing it with latex extracted from *L. kirkii* stem to become a complete birdlime	14.7

Air blown	Milky latex	Collected latex, excluding those extracted for species under genus *Euphorbia* L., is blown by air for about 30 minutes or until becoming thick and sticky, depending on weather condition. As like all the birdlime processing procedures in the Vhembe Biosphere Reserve, the thick and sticky substance, then undergo strengthening using latex extracted from *L. kirkii* stem	29.6
Total (%)			**100**

Table 4.8: Complementary uses and contribution of birdlime to human development, based on the informant's perceptions within the Vhembe Biosphere Reserve, in the Limpopo Province, South Africa

Uses and contributing value	Informants category						%
	Environmentalists	**Escorts for traditional health practitioners**	**Farmers**	**Hunters**	**Laypeople**	**Traditional health practitioners**	
Trapping small birds (Bird hunting): Nutritional value	3	6	21	8	39	16	45.8

Making of roof-waterproofing: Human shelter development and repair	2	3	4	1	12	6	13.8
Adhesion: Either as glue and paper sticker	2	5	7	1	24	8	23.2
Teeth cleaning or whitening for humans (Note: Only birdlime made from the milky latex of *L. kirkii* is used): Human health	0	6	1	0	9	19	17.2
Total (%)							**100**

Indigenous conservation practice in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Indigenous conservation mechanisms and its basis

Local people in the Vhembe Biosphere Reserve use various mechanisms to conserve useful threatened plant species. Table 4.9 illustrates indigenous conservation mechanisms used by the Vhembe Biosphere Reserve people. A total of eight indigenous conservation mechanisms cited by informants were recorded (Table 4.9). The recorded conservation mechanisms include, the harvesting of single lateral root per individual medicinal plant (15.3%), harvesting of medicinal and timber materials only during the winter season (16.7%), the use of moist soil to cover injured plant part after bark harvesting (18.2%), harvest of medicinal materials from an injured plant is prohibited (11.8%), the collection of dried and fallen plants are collected for firewood (8.4%). Furthermore, all collection of medicinal materials and timber are permitted by the traditional council through the chief or headman (9.9%), while chopping down of any medicinal plant species is prohibited and punishable (13.8%) and the collection of some Critical Endangered plant species such as, *Brackenridgea zanguebarica* Oliv., and *Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt, only occurs during the midnight by authorized and designated people only (5.9%) (Table 4.9).

Informants in the present study indicated that indigenous conservation mechanisms used to sustain the viability of botanical resources in the Vhembe Biosphere Reserve are divided into five meaningful strategies, including, selective harvesting, seasonal timing and maintenance of plant's wellbeing, as well as care when harvesting and only authorized people to harvest (Table 4.9). Indigenous conservation execution in the Vhembe Biosphere Reserve, likely incorporates specific conservation efforts to help achieve meaningful sustainability (Table 4.9). Indigenous conservation across the study region is likely executed heterogeneously and therefore, about 75% of the conservation mechanisms are applied indirectly. Informants ubiquitously perceived the importance of indigenous conservation mechanisms as an effort to enhance the sustainability and viability of useful threatened plants in the Vhembe Biosphere Reserve, Limpopo Province, South Africa.

Table 4.10, illustrates the basis of indigenous conservation as viewed by informants. The majority (65.1%) of informants emphasized that the basis of indigenous conservation promotes the guardianship and compliance at the local level and also to reduce the unnecessary harvesting of botanical resources, including these plants of high conservation concern. Nevertheless, other informants (34.9%), highlighted that indigenous conservation brings socioeconomic transformation to them and it also promotes sustainability and viability of useful threatened plant species (Table 4.10).

Table 4.9: Indigenous conservation mechanisms used by local people in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Conservation strategies	**Guideline strategies**	**Efforts**	**Application of mechanism**		**Informant's citation (%)**
			Direct application	**Indirect application**	
Harvest of single lateral root per individual medicinal plants	Selective harvest	To prevent plant from falling down during the windy season, as well as allowing it to continue extracting nutrients, minerals and water from the soil	Yes	-	15.3
Medicinal materials and timber, are harvested during winter season	Seasonal timing	To avoid disturbance during reproductive season	-	Yes	16.7
The use of moist soil to cover the injured plant part after harvest	Insuring plant's wellbeing	To promote rapid recovery and prevent the plant from getting dried out, as well as getting decayed	Yes		18.2

Harvest of medicinal materials from an injured plant is prohibited	Carefulness harvest	To allow the harvested individuals to recovery before any attempt of re-harvesting	-	Yes	11.8
Only dried and fallen plants are collected for firewood	Selective harvest	To prevent deforestation of useful threatened plant species	-	Yes	8.4
All collections of medicinal materials and timber are permitted by the traditional council through the chief or headman	Authorized/ permissible harvest	To prevent over-harvesting of certain plant species	-	Yes	9.9
Chopping down of any medicinal plant species is prohibited and punishable	Authorized/ permissible harvest	To prevent deforestation of useful threatened plant species	-	Yes	13.8
Collection of some Critically Endangered plant species, including *Brackenridgea zanguebarica* Oliv.,	Authorized/ permissible harvest	To prevent over-harvesting of these species	-	Yes	5.9

and *Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt, only occurred during the midnight, by certain and authorized people only					

Table 4.10: Basis for indigenous conservation strategies as per informant's perceptions

Basis	Laypeople	Traditional health practitioners	Farmers	%
It promotes guardianship and compliance at the local level	47	11	9	35.0
It also limits the harvest of unnecessary threatened plant materials	34	15	16	30.1
It brings socio-economic transformation to rural dwellers	25	3	6	16.7
It promotes sustainability and viability of useful threatened plant species	16	19	2	18.2

Strategies used to ensure compliance of conservation

Informants have reported that observation of various conservation measures in the Vhembe Biosphere Reserve are often facilitated through various strategies including, community bylaws (45.3%), followed by, cultural beliefs (29.5%), ritual observations (23.2%) and also cultural norms and myths (2%) (Figure 4.5). The frequent use of community bylaws implies that some local people in the Vhembe Biosphere Reserve are modernized.

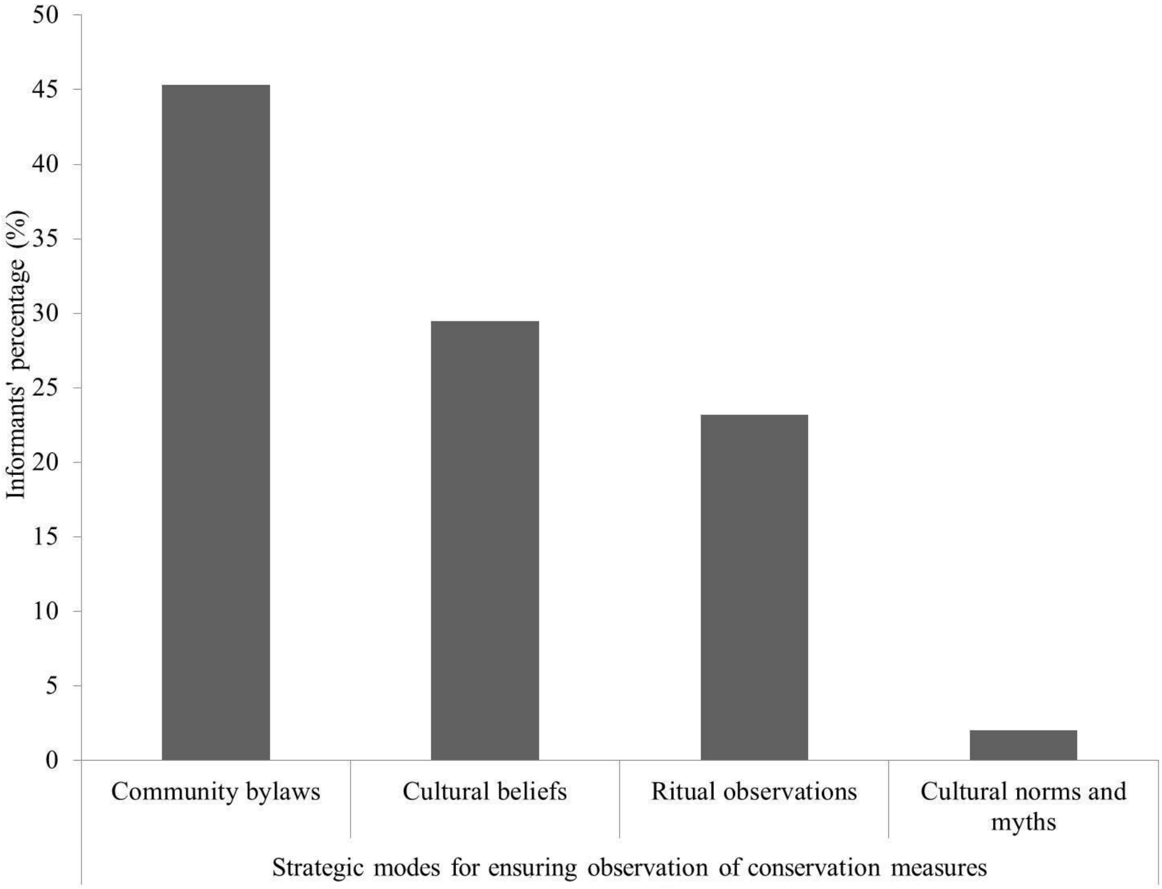

Figure 4.5: Strategic modes used to enforce observation pertaining conservation measures.

Informants reiterated that enforcing conservation measures is not a simple task for them, although it remains ideal in sustaining the viability of useful threatened plant species in their area. Informants also attested that the majority of young people in the Vhembe Biosphere Reserve are reluctant to abide by some important strategic mode, including ritual observations, cultural norms and myths.

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CHAPTER FIVE

DISCUSSIONS

Chapter Five: Discussions

The inventory of useful threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

The IUCN's conservation status of plants is considered important for enforcing the international laws, including treaties and conventions, whereas, SANBI's conservation status enforces the national regulations (Raustiala and Victor, 1996; Raustiala, 1997; Messer, 2010; Trouwborst, 2010; de Oliveira et al., 2011). It has been a common understanding that threatened plant species are aligned with either national or international conservation status (Czech and Krausman, 1997; Possingham et al., 2002). The fact that tree species seemed to be likely more abundant in the forest, rather than in any other biome (Slik et al., 2015; Sun et al., 2017), reaffirm why Lauraceae species were only found in the Thathe Vondo forest. The diversity of threatened plant families reaffirms the evidence that indeed the Soutpansberg Site of the Vhembe Biosphere Reserve in the Limpopo Province, South Africa is a biodiversity hotspot (Küper et al., 2004; Reyers, 2004; Clark et al., 2011; Moraswi et al., 2019; Hahn, 2019; Bamigboye and Tshisikhawe, 2020). In spite that some vernacular names cited by the participants were firstly recorded in the current study, all the recorded threatened plant species have their Tshivenḓa names and this demonstrates their local values. In the Soutpansberg Region, usually the vernacular names for the folk medicinal plant species used by the Vhavenḓa ethnic group are associated with the name the ailments that they treat (Personal communication with the recruits). For example, the Tshivenḓa vernacular name of the species *Ocotea bullata* (Burch.) Baill., is called "*Mulafhadali*", and it means the malaria healer, with the prefix "*Mulafha-*", meaning the healer in Tshivenḓa language and the suffix "-dali", meaning the malarial infection. Maroyi and Maesen (2013) affirmed that the vernacular names of plant species, imply their usefulness, since folk people hardly name plant species that they do not utilize. The UV, of threatened plant species, was pivotal for evaluating the most useful species as compared to their counterparts in the same sample (Umair et al., 2017; Setshego et al., 2020). The RFC is the summation of the threatened plant's reported uses based on the participant's citations for certain species without considering the use categories (Kankara et al., 2015; Mwinga et al., 2019). The FL value is used for evaluating the level of significance of the useful threatened plant species within the studied region and therefore, this shows the proportion between the number of participants who claimed the use of threatened plants for similar significant purpose and all participants who cited those plants for any other purpose (Khan et al., 2014; Tuttolomondo et al., 2014; Kayani et al., 2015; Dembélé et al., 2015). Moreover, the aforementioned ethnobotanical induces (UV, RFL and FL) were strategically used for identifying the most significant and useful threatened plant species within the studied region (Farooq, 2019; Atyosi et al., 2019). Despite the availability of good and well-established regulations to help preserve, protect and restrict the utilization of threatened plant species in South Africa (Foden, 2007), *W. salutaris* and *B. zanguebarica* remain the mostly demanded species in the region. Although, this study lacks phytochemical and pharmacological evaluations, Mothupi (2014) and Ramarumo et al. (2019c), reiterated that African people in poor and marginalized communities usually utilized herbal medicines due to their therapeutic efficacy, viability, and reliability. Kurande et al. (2013), considered utilization and administration of herbal medicines in aboriginal cultural communities as completely experimental, whereas, Tengö et al. (2014), reported that traditional healing mechanisms required no validation of its phytochemical constituents, since it is trustworthy and it has been validated long-time ago through trial-error-experiments. Moreover, this study argued that high FL (%) value of *W. salutaris* and *B. Zanguebarica* delineates that folk knowledge associated with their use is common and well-known to the majority of dwellers within the studied region. Literary to the study done by Tshisikhawe et al. (2013), over-harvesting of such an important plant species could eventually lead to the deterioration of their population structure and conservation status. According to Schatz (2009), a decline in the number of useful threatened plant species could also negatively impact the livelihood chain and the provision of traditional health care in rural and marginalized communities.

Gosling et al. (2017) and Magwede et al. (2019) elucidated that local people in the Southern African Region, utilizes various plant resources for their various livelihood needs (Michler et al., 2019). The frequent utilization of tree species was therefore not uncertain, since other studies done in the region also reported the similar results (Leshabana and Tshisikhawe, 2019). It is worthy indicating that local people in the Soutpansberg Site of the Vhembe Biosphere Reserve in the Limpopo province, South Africa had adopted their own and diverse livelihood strategies that include, frequent utilization of plant forms that have multi-useable parts and long life span (Personal communication). According to Kunwar et al. (2010), local people in rural and marginalized remote communities usually develop various livelihood strategies that suit their needs. Therefore, the frequent utilization of tree species in the studied region was also influenced due to its multi-usage forms and long life span. Although the results of the present study seemed to be in accordance with other studies in the region (Rampedi and Olivier, 2013; Muhali, 2017; Tshisikhawe and Malunga, 2017; Ndhlovu et al., 2019), it is worth to argue that over-harvesting of threatened plant species could cause a decline in their population size and eventually rapid extinction. The South African National Biodiversity Institute (SANBI), an affiliate to the IUCN, considered the vegetation status of the Thathe Vondo as vulnerable (Munyati and Sinthumule, 2014) with some little patches of pristine ecosystems within. The fact that the majority of threatened plant species in the studied region were distributed in the Thathe Vondo area, was because those species are considered sensitive to climate change, and therefore, remote and high elevation areas create a suitable micro- climate for their survival (Telwala et al., 2013). Furthermore, Thathe Holy Forest is also considered one of the strictly conserved and pristine forest in Southern (Araia and Chirwa, 2019a; Araia and Chirwa, 2019b). Since more threatened plant taxon were recorded in high elevated areas, the present study argued that threatened plant species richness in the Soutansberg Site of the Vhembe Biosphere Reserve in the Limpopo Province, South Africa, increased with an increase in elevation, annual rainfall and habitat viability. This was endorsed by both local and international scholars (Lobo et al. 2001; Vetaas and Grytnes 2002; Bruun et al. 2006; Munyati and Sinthumule 2014). The recorded coordinates of threatened plant species location could strengthen their future monitoring in the region. Whittaker et al. (2005), uttered that spatial information, including the use of GPS coordinates play an important role in modern conservation and monitoring. The fact that results in the current study demonstrated habitat transformation and over-harvesting as the major threats to the species of high conservation concern, was also illustrated in other literature studies (Du Toit et al., 2016; Heinrichs et al., 2016; Boon et al., 2016; Leroux et al., 2017; De Kort et al., 2018). Data about the population size of adult threatened plant species is considered crucial for either upgrading or downgrading the conservation status of the species, using version 3.1 of the IUCN's Red List Categories and Criteria (IUCN, 2012; Williams et al., 2013). Although the population size of *D. sylvatica* seemed to be over 300 individuals, this species remained vulnerable to extinction risk since its combined area of occupancy within the studied region was approximately < 500 m^2. Although the conservation status of *D. sylvatica* is only recognized nationally, the Categories and Criteria of the IUCN's Red List suggest that small distribution range, area of occupancy and other ecological aspects, implies that the species is on the verge of extinction risk (IUCN, 2012). Due to the fact that 61.54% of all the recorded threatened plants seemed to be having the population size of < 100 adult individuals, it is therefore, argued that the smaller the population size of individuals of threatened plants in a single area of occupancy, the more vulnerable towards the verge of extinction they become (IUCN, 2012). *Brackenridgea zanguebarica* is considered Critically Endangered in South Africa and its distribution range is restricted to a single geographic area or area of occupancy called Thengwe (Tiawoun et al., 2019).

Therapeutic uses, preparation and administrative techniques of *Warburgia salutaris* (G. Bertol.) Chiov., *Asparagus sekukuniensis* (Oberm.) Fellingham & N.L.Mey. and *Bowiea volubilis* Harv. *ex* Hook.f. subsp. *Volubilis*

Warburgia salutaris is one of the highly demanded plant species, not only in the Soutpansberg Region of the Vhembe Biosphere Reserve, but also in the entire Southern African Development Community Region (SADEC) (Maroyi, 2013; Kotina et al., 2014; Maroyi 2014; Leonard and Viljoen, 2015). Based on the results of the current study, it is therefore, arguable that its demand could be aligned with its potential to treat the assorted ailments. The therapeutic ability of *W. salutaris* in treating the assortment of ailments is based on combination with other medicinal remedies. Zhou et al. (2016) and Bhokare et al. (2016) emphasized that the fundamental way to achieve rapid healing, is increasing the therapeutic efficacy. The findings of the current study were supported by Ngarivhume et al. (2015), who emphasize that the combination of various herbal remedies is prevalent among African traditional health care systems. The mixing of *W. salutaris* with other herbal remedies emphasizes the wealth of ethnopharmacological knowledge that local herbal practitioners possess in the study area (Olivier and van Wyk, 2013). The use varied pharmacological preparation method and administration processes of *W. salutaris* was informed due to the fact that the African traditional medicines varied in their preparation and administration depending on the nature of ailments to be treated (Mahomoodally, 2013). This was also supported by Gurib-Fakim (2006), who articulated that difference illnesses varied in their treatment procedures. The use of boiling in the pharmacological preparation of *W. salutaris* was also endorsed by Coopoosamy and Naidoo (2012), who emphasize the reliability of boiling in the traditional therapeutic preparation method. Oral mode was the most preferred method in the administration of *W. salutaris* because it is cost effective and requires no supervision by practitioners (Bartel, 2007). The difference in the devotional period and medicinal dosage used from patient to patient proved that traditional therapeutic means is not static, but dynamic (Dold and Cocks, 2000). This was also emphasized by Arnold and Gulumian (1983). The fact that the bark was demonstrated as the most preferred used *W. salutaris'* part aligned with other ethnomedicinal studies done in the Sesheke District, Western Province, Zambia and Sekhukhune District, Limpopo province, South Africa (Semenya et al., 2013; Chinsembu, 2016).

Asparagus sekukuniensis appeared to be an important herbal medicine against infant ailments, wounds, infections, and infestations. Participants emphasized that ensuring infant health care is always an important cultural norm for the Vhaveṋḓa people in the region. Therefore, all the newly born infants undergo traditional vaccination rituals to strengthen their immune systems called *muthuso* (personal communication with the participants). Rikhotso (2016), herein define *muthuso* as the use of varied herbal medicines to protect the infants against miscellaneous ailments. The common uses of *A. sekukuniensis* by the traditional health practitioners in the region proved its effectiveness and therapeutic ability. This was also suggested by Semenya and Maroyi (2019), who indicated that the communal utilization of certain medicinal plant species by various herbal healers proves the therapeutic reliability of the implicated species. Thus, the current study therefore, argued that the repetitive use of *A. sekukuniensis* in addressing miscellaneous ailments demonstrates the variety of biological activities it may have possessed. This was endorsed by other scholars worldwide (Cheikhyoussef et al., 2011; Khan et al., 2014; Mojahedi et al., 2014). Nevertheless, Jamila and Mostafa (2014), emphasized that the reliability of traditional herbal medicines in the treatment and prevention of certain ailments, should not be doubted, but phytochemically validated for authenticity. The equal utilization proportions of *A. sekukuniensis* parts were influenced by the fact that healers do not want to lose any materials from this species, since this plant is considered scant to be found (personal communication). This was also endorsed on the study done by Burrows et al. (2016), whereby *A. sekukuniensis* was categorized as an endangered species under the International Union for Conservation of Nature. Furthermore, this study argued that equal utilization of *A. sekukuniensis* parts demonstrates the equal therapeutic efficacy (Ramarumo et al., 2019). Moreover, the results of this study do not seem to conform to other ethnomedicinal studies in the region, since leaves and bark was portrayed as the most frequently utilized plant part (Mulaudzi et al., 2012; Luseba and Tshisikhawe, 2013; Mahwasane et al., 2013; Masevhe et al., 2015). Nevertheless, so far there is no evidence in literature stipulating ethnomedicinal uses of *A. sekukuniensis* in South Africa and elsewhere.

The present study has unveiled novel evidence about the therapeutic uses associated with the utilization of *B. volubilis* in the Soutpansberg Region, Vhembe Biosphere Reserve, of the Limpopo Province, South Africa. *Bowiea volubilis* seemed to be an important herbal medicine for infant diseases, women's diseases, organ infections and tissue treatment. The use of decoction as the most preferred therapeutic preparatory method by the traditional healers was influenced due to its simplicity (Ngarivhume et al., 2015). This was consistence since other scholars worldwide also reported similar results (Bhokare et al., 2016; Zhou et al., 2016; Sun et al., 2017). The therapeutic use of *B. volubilis* by traditional healers against assorted diseases delineates the potential bioactive compounds it may possess, dynamism within the traditional therapeutic means and the wealth of pharmacological knowledge that traditional healers of the study areas possessed. Findings of this study seemed to corroborate to other literature studies in the same field (Duncan et al., 1999; Nesamvuni et al., 2001; Van Wyk et al., 2008). Louw et al. (2002), emphasize that species under family Hyacinthaceae including *B. volubilis* contains large amount of bioactive compounds. Regardless of the fact that the current study lacks phytochemical validations, Tengö et al. (2014), argued that indigenous therapeutic knowledge requires no validations since it has already been validated by our ancestors during its developmental stages, through trial-era-experiment. However, Jamila and Mostafa (2014), emphasizes the fact that herbal therapeutic efficacy should not be doubted, but pharmacological evaluated for its precisions. Furthermore, the therapeutic use of *B. volubilis* against multiple diseases also demonstrates the high level of its demand across the study sites. Therefore, this study argued that the continuous unsustainable harvest of *B. volubilis* for any purpose within the region could potentially have devastating impacts on its population size and eventually driven towards the verge of more extinction risk.

Birdlime-making plant species: Techniques, synthetic procedures, uses and complementary contribution to human development in the Vhembe Biosphere Reserve, Limpopo Province, South Africa

According to informants, the use of various plant species in the birdlime-making has been part of the Vhavenda people's indigenous conservation strategy to reduce harvesting pressure among useful species (Personnel communication with the informants). This seemed to be certain since literature suggested that ethnobotanical use of diverse plant species demonstrates wisdom, dynamism and alternatives (Kunwar et al., 2015). The frequent utilization of family Laranthaceae and Euphorbiaceae was buttressed due to factors such as distribution, species diversity within these families and their abundance in the study areas. Previous studies reported that Euphorbiaceae is a diverse and largest family within the flowering plants and it contained over 2000 species (Ernst et al., 2015), whereas, family Loranthaceae is considered to have 950 species and 77 genera (Didier et al., 2009). High percentage level of informants who cited *M. peduncularis, E. pulvinata* and *L. kirkii* demonstrated the certainty of common knowledge associated with their uses in the study areas. According to the informants, it is commonly known that birdlime derived from either *M. peduncularis* or *E. pulvinata* considered to be lasting, reliable and strong, only if it is subjected to the strengthening process using latex of *L. kirkii* (Personal communication with the informants). This was supported by Magwede *et al*. (2018), who uttered that *L. kirkii* plays a pivotal role in the birdlime strengthening. The fact that milky latex was the most preferred plant part in birdlime-making concur with the results of the study done by Pakia et al. (2003). Although, indigenous knowledge pertaining birdlime-making plant species seemed to be prevalent across the Vhembe Biosphere Reserve, instant transmogrified lifestyle tends to gradually erode this precious knowledge unnoticed. Mokganya et al. (2018) emphasized that urbanization and change in rural lifestyle gradually erode local knowledge and traditional cultures.

The use of diverse techniques in the synthesis of birdlime demonstrates the high level of ingenuity and innovativeness amongst dwellers of the studied region. Literature studies suggests that ingenuity had never been something optional to dweller living in scant resource communities, rather adaptive for sustaining livelihoods in those communities (Ramarumo et al., 2019). Dold and Cocks (2000), reiterated that indigenous knowledge pertaining the utilization of plant species is not inert, rather dynamism and adaptable. Similar to our finding, Kunwar et al. (2005) and Platt et al. (2012), emphasize the use of various plant parts in birdlime making. However, their studies never specify its preparation and synthetic techniques. Consistent with the findings of the current study, literature studies seemed to be corresponding with the use of birdlime for trapping or hunting of small birds (Platt et al., 2012; Suriati et al., 2018). Unfortunately, there is no literature evidence suggesting the other complementary uses of birdlime and its synthetic procedures, except being air-blown. This demonstrates the contribution of the current study on enhancing the present scientific knowledge about birdlime-making. So far, there is no literature study that has ever reported about birdlime-making and its complementary contribution to human development in the Southern Africa.

Informants reiterated that they have accumulated their knowledge about utilization and conservation of botanical resources from their forefathers. Indigenous knowledge systems, including the wealth of knowledge about utilization of natural resources and conservation was firstly accumulated by ancestors through harmoniously living with the natural world over the historical period of time and consequently preserved generationally (Gadgil et al., 1993; Mutshinyalo and Siebert, 2010; Ross, 2017; Mashile et al., 2019; Araia and Chirwa, 2019b). The frequently cited conservation mechanisms, including those with informant's citation percentage > 11.8% demonstrate that indigenous conservation knowledge in the studied region is likely prevalent. According to Ntuli (2002), there is a noticeable commonality within indigenous knowledge amongst African communities in Southern Africa. Informants emphasize that mostly conservation knowledge associated with sustainability of threatened medicinal plant species is likely rooted on certain people and their lineage. This corroborates the study done by Tshisikhawe (2013), and therefore, it was highlighted that only certain people are allowed to participate in the collection of *B. zanguebarica*. The results in the current study demonstrated that local people, especially traditional health practitioners within the study area, hardly utilize injured threatened medicinal plants. This was underpinned by the fact that traditional health practitioners across the study area believed that utilization of an injured-threatened medicinal plant, could possibly have devastating impacts on their patients, and consequently made them to be slowly healing or eventually die. The results of the current study likely concur to other studies done in the region (Arnold and Gulumian, 1984; Mabogo, 2012). The fact that indigenous conservation mechanisms includes the strategic guidelines cited on table 2, explained the basis and efforts of indigenous people in ensuring the sustainability of useful threatened plant species across the Vhembe Biosphere Reserve. Stoll-Kleemann et al. (2010) uttered that usually community conservation resulted in the high level of compliance. Araia and Chirwa (2019b), emphasized the prominent role of indigenous knowledge in the management of biodiversity, whereas, Spenceley et al. (2019), recognizes the contribution of folk community guardianship in the conservation and management of biodiversity. The incorporation of specific efforts in the indigenous conservation is of relatively importance for bringing realistic conservation outcomes and maintaining harmonious coexistence of people and nature within the biosphere reserve (Raviv et al., 2020). The views that the basis of indigenous conservation is to encourage community guardianship of natural resouces, promote conservation compliance at the local level and reduce unnecessary harvest of those resources. This also demonstrates the relevancy of indigenous knowledge in today's conservation agenda. This was supported by Fu et al. (2004), who referred community-based conservation as an initiative that promotes local accountability. Nevertheless, the view that indigenous conservation practises brings socioeconomic justice and transformation to local people substantiate the results on the study done by Ferreira (2004) and DeGeorges and Reilly (2009). Local people of the Vhembe Biosphere Reserve have their own strategies in place to enforce the observation of conservation measures. Ramarumo et al. (2019), highlighted that searching for an innovative solution that could sustain scant resources is not something optional, but mandatory among rural dwellers across the Vhembe Biosphere Reserve. Literature studies also inform that dwellers in the remote region depend upon indigenous knowledge (Shah et al., 2020) to sustain resources.

The use of community bylaws and cultural believe to enforce compliance of conservation measueres demonstrates adaptability, flexibility and dynamism within indigenous local communities across the Vhembe Biosphere Reserve. The use of various strategies to ensure the observance of onservation measures validates dynamism within indigenous conservation knowledge of the study area (Kunwar et al. 2015; Ramarumo et al. 2019). Findings of the current study corroborate to those reported on the study done by Gadgil et al. (1993). Nevetheless, the frequent use of community bylaws also implies the fact that some local people in the Vhembe Biosphere Reserve tend to be modernized. It further attested that indigenous knowledge about the conservation of useful threatened plant species is not static, but adaptive (Dold and Cock, 2000; Maroyi, 2017), whereas, the use of cultural beliefs further demonstrates the existence and prevalence of indigenous culture in the region. Mokganya et al. (2018) highlighted that the lifestyles of many dwellers in the Vhembe Region seemed to be gradually modernizing, whereas, Ramarumo et al. (2020), emphasized that the instant change in people's lifestyles could gradually lead to an indigenous cultural dilution, rather than transformation. Therefore, this study argued that indigenous bylaws and cultural beliefs likely influence perceptions about conservation of useful threatened plant species (Williams et al., 2019). According to Netshiungani and Van Wyk (1980), the conservation of the useful threatened plants in the Vhembe Region is mainly rooted in cultural beliefs. The fact that the informants in the current study attested that enforcing dwellers to abide by community conservation measures remains a stumbling block, was also emphesized in the study done by Müller (2020). The disorbidince of young people when it comes to abiding by indigenous conservation measure in place, was influenced due to social stigma attached to the use of folk knowledge in resolving biodiversity problem (Njiraine et al., 2010; Dweba and Mearns, 2011; Ruheza and Kilugwe, 2012; Moyo, 2013; Bvenura and Afolayan, 2014). Some scholars reported that the denouncement of indigenous Africa knowledge during the apartheid era has left an inherent stigma, amongst many black communities in South African (Mutshinyalo and Siebert, 2010; Nemutandani et al., 2016). Some informants emphasized that ritual observations plays a central role amongst traditional health practitioners in the region, prior to them collecting medicinal plant materials, whereas, cultural norms and myths are mostly appreciated by elderly people in Vhembe Biosphere Reserve. Such kind of practise was also been observed in other parts of the Limpopo Province, including, Capricorn, Sekhukhune and Waterberg District Municipalities (Semenya and Maroyi, 2019). Tshisikhawe et al. (2012), affirmed that traditional health practitioners and elderly people still observe rituals whenever they collects botanical resources. Previous studies considered traditional health practitionars and elderly people as the utmost custodians of indigenous traditional knowledge system (Govender et al., 2013; Risiro et al., 2013; Mathibela et al., 2015; Maluleka and Ngulube, 2018). The current study serve as a vantage point to comprehend indigenous conservation knowledge and dynamics associated with the utilization that ensure conservation of threatened botanical resources in the Vhembe Biosphere Reserve. This could be beneficial for an inception and formulation of more indigenous-friendly conservation policies, regulations and bylaws that allows harmonious coexistence of people and nature in South African biosphere reserves, including the Vhembe Biosphere Reserve. Local people of the Vhembe Biosphere Reserve perceived indigenous conservation practises as their integral heritage without any intricacy. This study argued that incorporating indigenous conservation knowledge associated with utilization of botanical resources into the national conservation agenda could potentially reduce poaching and possibly promote bioprocessing of botanical resources to increase the country's growth domestic products

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CHAPTER SIX

CONCLUSION, CONTRIBUTION TO SCIENTIFIC KNOWLEDGE AND RECOMMENDATIONS

Chapter Six: Conclusion, contribution to scientific knowledge and recommendations

Conclusion

The current study provides substantial information about useful threatened plant species, their distribution range and values linked to the improvement of local livelihoods and development. The hypothesis which stated that traditional knowledge about utilization, distribution and conservation statuses of threatened plant species provide suggestions for appropriate conservation practices can therefore, not be rejected as there is room for further and more detailed ethnobotanical investigations that is focused on human interactions with threatened plant species. In the Vhembe Biosphere Reserve, Limpopo Province, South Africa, local people do not perceive the values derived from threatened plant species as separate from their desire to improve their own livelihoods and daily strive for civilization. The data presented in this thesis could be used as baseline information for formulating new conservation strategies, monitoring and management plans of threatened plant species not only in the Vhembe Biosphere Reserve but in other regions of South African. This study provided insights associated with ethnomedicinal uses of *Asparagus sekukuniensis*, *Protea laetans* and *Encephalartos hirsutus*. Results of this study could also stimulate interest in other scientific disciplines such as the phytochemistry, pharmacology, bioprocessing, conservation and anthropology involving documented threatened plant species. Although the utilization of threatened plant species seemed to be pivotal for the improvement of local livelihoods in the Vhembe Biosphere Reserve, this study therefore, recommended the re-evaluation of the conservation status of highly utilized species within the studied region.

Contribution to scientific knowledge

Accordingly, this piece of work presents the first comprehensive contribution of compiled data associated with threatened plant species utilization, conservation status and spatial information related to their exact location of distribution in the Vhembe Biosphere Reserve, Limpopo province, South Africa. The study of this nature was never being done before and since the establishment of the Vhembe Biosphere Reserve by the UNESCO in 2009 and to date. The potential contribution of the current study is based on the following aspects:

(a) Data presented in the current study is of great local value and therefore, such data could be significantly used as a template for future global works, including the assessment or re-assessment of threatened plant’s conservation status.

(b) Since the 2020 Global Strategies for Plant Conservation has expired in 2020 (GSPC, 2020), the data presented in the current study is of crucial value and it could be used as baseline to inform readdress and renewal of new strategies, particularly the following targets:

(i) Target 2: which was devoted to an assessment of the conservation status of all the known plant species to inform conservation action (GSPC, 2020),

(ii) Target 9: which elucidate that 70% of the genetic diversity of crops, including their wild relatives and other socioeconomically valuable of plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge (GSPC, 2020),

(iii) Target 13: which elucidates that indigenous local knowledge, innovations, and practices associated with plant resources, maintained or increased as appropriate to support customary use, sustainable livelihoods, local food security and health care (GSPC, 2020),

(iv) Target 14: that elucidate the importance of plant diversity and the need for their conservation incorporated into communication, education and public awareness programs (GSPC, 2020).

(c) For the first-time in South African biosphere reserves this study presented spatial data related to the exact geographic location of where threatened plant species distributed in the Vhembe Biosphere Reserve. Spatial information about specific species location simplify the conservation and monitoring process. This information could also be used as a baseline for formulating new conservation strategies, monitoring and management plans, not only in the Vhembe Biosphere Reserve, but in all South African biosphere reserve since studies of this nature seemed to be lacking (Jauro et al., 2020).

(d) The current study represents a significant contribution to the current knowledge on the traditional uses and conservation of plant resources classified as threatened.

(e) For the first-time in the history of ethnobotanical studies, this study provided insights associated with ethnomedicinal uses of *A. sekukuniensis*, *P. laetans* and *E. hirsutus*. No study have, ever elucidated such ethnomedicinal uses, either in South Africa or elsewhere. This study further outlined the ethnobotanical use of *H.*

nouhuysii in the birdlime-making, and also documented birdlime-making plant species, birdlime-making techniques, synthetic procedures and its complementary contribution to human development in the Vhembe Biosphere Reserve. This was never been recorded in South Africa and elsewhere. Findings presented in the current study are of great interest, not only for the sake of preserving indigenous cultural heritage or promoting economic subsistence amongst dwellers within the Vhembe Biosphere Reserve, but stimulating scientific interest in areas of studies that include phytochemistry, pharmacology, economic-botany, bioprocessing, conservation and anthropology.

(f) This study has also outlined indigenous ways to help conserve plant resources. This could be used to inform the establishment of integrated conservation strategies and management plans that ensures harmonious coexistence of people and nature, not only in the Vhembe Biosphere Reserve, but also in South African biosphere reserves as a whole, since such knowledge was lacking before (Jauro et al., 2020). This could also serve as a baseline for redress of conservation regulations and policies in South Africa, while promoting the acceptability of indigenous cultural heritage.

Recommendations

Due to the resource constraints and time scheduled for the completion of the current study, its scope was limited to address certain key objectives, leaving other aspects as recommendations for future studies, readdress by government or lawmakers, traditional leaders and conservation managers. In this regards, the current study, therefore, recommended the following aspects:

(a) Future studies that need to be done

(i) A study on phytochemical constituents and pharmacological properties of less studied threatened medicinal plants including *A. sekukuniensis, P. laetans and E. hirsutus* could aid with the provision to validate their ethnomedicinal usage, while paving the path towards processing these species into marketable products. This could not only contribute to scientific knowledge, but also to the country's Growth Domestic Products (GDP) during this time of recession,

(ii) A study on specific ethnomedicinal uses of some threatened plant species documented in the present study is also recommended, since this could lead to novel drug discovery.

(iii) Since the scope of current study was intended to address limited research objective, a study on phytosociological status of threatened plant species in the Vhembe Biosphere Reserve is also recommended. Such study should include information about the area of concentration of threatened plant species and the relationship between the threatened species richness and the overall plant species richness,

(iv) Since indigenous people are known to conserve what they usually use (Araia and Chirwa, 2019; Thomson et al., 2020), a study on evaluation of threatened plant's economic implications is recommended, since it could bring social and economic justice to the people, while, promoting the heritage of conserving valuable plants using various mechanisms such germination and propegation amongst indigenous communities within South African biosphere reserves,

(v) Although utilization of threatened plant species in the Vhembe Biosphere Reserve seemed to be bringing livelihood benefits, it is highly recommended that the conservation status of highly utilized plant species including *B. zanguebarica* and *W. salutaris* should be re-evaluated and monitored, at least at the seasonal basis,

(vi) A study on population structure of seedlings and juvenile threatened plants in the Vhembe Biosphere Reserve is also recommended. This could be used as a vantage-point when making future scientific predictions about threatened plants in the region.

(b) Recommendations for either government or lawmakers

(i) The government should recognize indigenous knowledge associated with conservation and subsistence utilization of threatened plant species by the local community within South African biosphere reserves. However, this should not prevent strict conservation measures and monitoring processes of threatened plant species found within the core zones of the biosphere reserves.

Therefore, the recognition of indigenous knowledge associated to utilizations that also ensure the conservation and sustainability of botanical resources could potentially minimize pouching of threatened plant species, enhance economic subsistence and strengthen compliance of conservation protocols at the local level,

(ii) Government should formulate policies that allow local people to utilize threatened botanical resources that only found within the buffer and transitional zones of biosphere reserves. This is necessary, since the main aim of the UNESCO biosphere reserves is to reconcile the conservation of biodiversity with their sustainable uses (UNESCO, 2019). This could also encourage the spirit of goodwill, social justice and reconciliation amongst the marginalized rural landless people and those who privately owns a large portion of the conservation land in South African biosphere reserves. This is also pivotal for minimizing the impact that could be felt, while waited for the land ownership question to be addressed in South Africa,

(iii) To minimize over-harvesting of plant resources, government should empower senior traditional leaders to either authorize or unauthorized the permits associated to plant material collections.

(c) Recommendations for traditional leaders

(i) Traditional leaders within the biosphere reserves should always monitor the utilization of threatened plant species within their jurisdictions,

(ii) Traditional leaders should also encourage their people to start adapting to the culture of germinating and propagating highly utilized threatened plant species in their homesteads as part of community conservation effort.

(iii) Traditional leaders should encourage their people to abide with customary norms and standards, while collecting threatened medicinal plant materials, since this promote sustainability of resources,

(iv) These customary norms and standards should be written and presented to all dwellers during the mass community gathering (usually occurred in most jurisdictions within the Vhembe Biosphere Reserve during the heritage day, every year). This could empower local people, particularly the youth with indigenous knowledge associated with conservation and sustainable utilization of botanical resources.

(d) Recommendation for conservation managers in South African biosphere reserves

(i) Conservation and management strategies for any biosphere reserve countrywide should not be informed by a single knowledge basis, rather multi-knowledge basis, including scientific and indigenous knowledge systems,

(ii) Adopted conservation strategies, monitoring and management plans should always cater for local needs.

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Appendix 1: Ethical approval

University of Fort Hare
Together in Excellence

ETHICAL CLEARANCE CERTIFICATE
REC-270710-028-RA Level 01

Certificate Reference Number:	MAR031SRAM01
Project title:	**Threatened plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa: Problems and prospects of conservation and utilization.**
Nature of Project	Doctor of Philosophy (Ethnobotany)
Principal Researcher:	Luambo J Ramarumo
Supervisor:	Prof A. Maroyi
Co-supervisor:	N/A

On behalf of the University of Fort Hare's Research Ethics Committee (UREC) I hereby give ethical approval in respect of the undertakings contained in the above-mentioned project and research instrument(s). Should any other instruments be used, these require separate authorization. The Researcher may therefore commence with the research as from the date of this certificate, using the reference number indicated above.

Please note that the UREC must be informed immediately of

- Any material change in the conditions or undertakings mentioned in the document;
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The Principal Researcher must report to the UREC in the prescribed format, where applicable, annually, and at the end of the project, in respect of ethical compliance.

Special conditions: *Research that includes children as per the official regulations of the act must take the following into account:*

Note: The UREC is aware of the provisions of s71 of the National Health Act 61 of 2003 and that matters pertaining to obtaining the Minister's consent are under discussion and remain unresolved. Nonetheless, as was decided at a meeting between the National Health Research Ethics Committee and stakeholders on 6 June 2013, university ethics committees may continue to grant ethical clearance for research involving children without the Minister's consent, provided that the prescripts of the previous rules have been met. This certificate is granted in terms of this agreement.

The UREC retains the right to

- Withdraw or amend this Ethical Clearance Certificate if
  - Any unethical principal or practices are revealed or suspected;
  - Relevant information has been withheld or misrepresented;
  - Regulatory changes of whatsoever nature so require;
  - The conditions contained in the Certificate have not been adhered to.

- Request access to any information or data at any time during the course or after completion of the project.

- In addition to the need to comply with the highest level of ethical conduct principle investigators must report back annually as an evaluation and monitoring mechanism on the progress being made by the research. Such a report must be sent to the Dean of Research's office.

The Ethics Committee wished you well in your research.

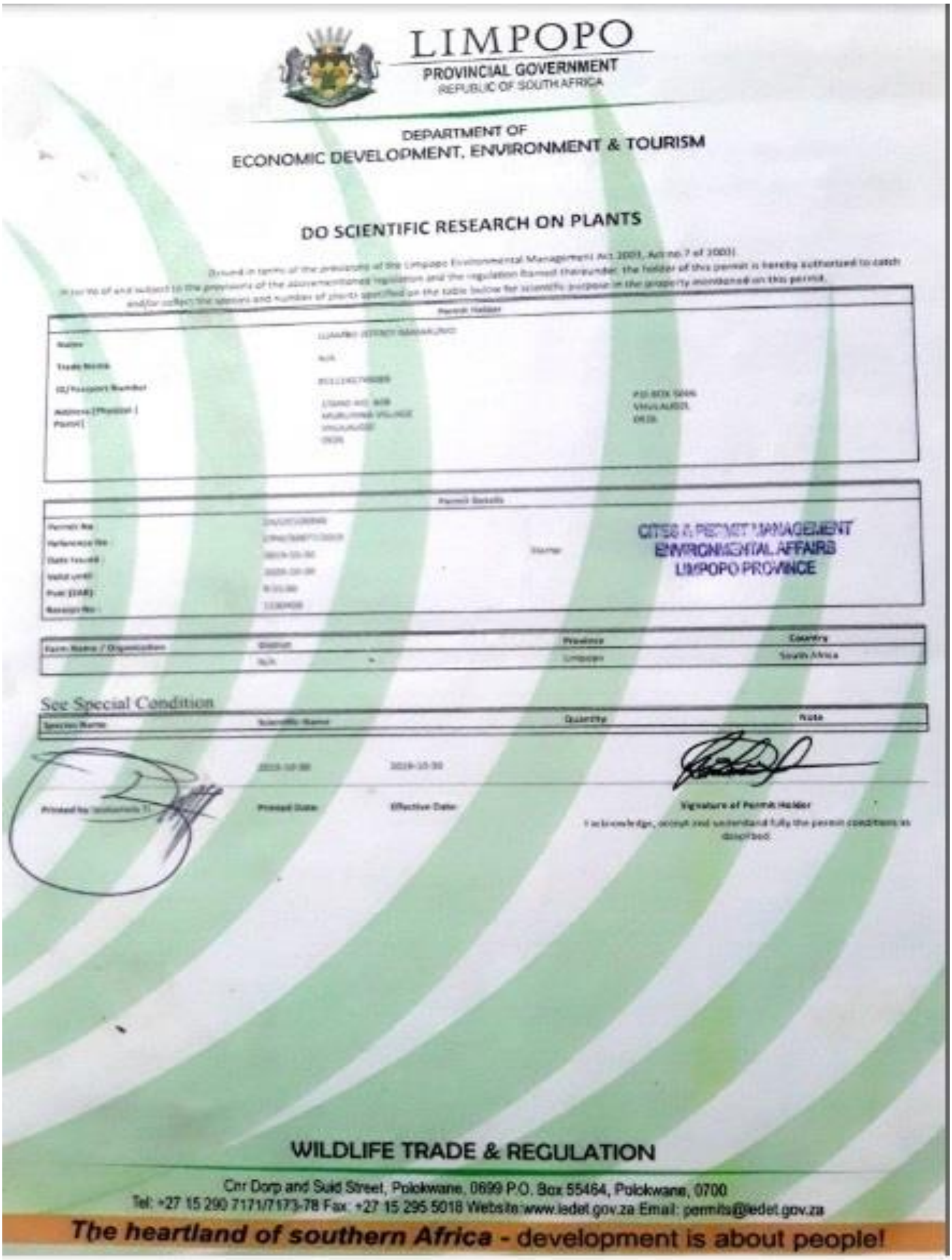
Yours sincerely

31/08/2018

Professor Pumla Dineo Gqola
Dean of Research

28 August 2018

Appendix 2: Specimen collection permits



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
ECONOMIC DEVELOPMENT, ENVIRONMENT & TOURISM

DO SCIENTIFIC RESEARCH ON PLANTS

Permit Holder

Permit Details

CITES & PERMIT MANAGEMENT
ENVIRONMENTAL AFFAIRS
LIMPOPO PROVINCE

See Special Condition

Signature of Permit Holder

WILDLIFE TRADE & REGULATION

Cnr Dorp and Suid Street, Polokwane, 0699 P.O. Box 55464, Polokwane, 0700
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DEPARTMENT OF
ECONOMIC DEVELOPMENT, ENVIRONMENT & TOURISM

DO SCIENTIFIC RESEARCH ON PLANTS

[illegible]

Permit Holder		
Name	[illegible]	
Trade Name	N/A	
ID/Passport Number	[illegible]	
Address (Physical / Postal)	[illegible]	[illegible]

Permit Details			
Permit No.	[illegible]	Stamp	CITES & PERMIT MANAGEMENT ENVIRONMENTAL AFFAIRS LIMPOPO PROVINCE
Reference No.	[illegible]		
Date Issued	[illegible]		
Valid until	[illegible]		
Paid (ZAR)	[illegible]		
Receipt No.	[illegible]		

Farm Name / Organisation	[illegible]	Province	Country
	N/A	Limpopo	South Africa

See Special Condition

Species Name	Scientific Name	Quantity	Note

	[illegible]	[illegible]	
Printed by: [illegible]	Printed Date:	Effective Date:	Signature of Permit Holder

I acknowledge, accept and understand fully the permit conditions as described.

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GENERAL CONDITIONS AND REQUIREMENTS OF PERMIT/LICENSE/CERTIFICATE

1. This permit or certificate shall not be transferable.
2. Any unauthorized alterations to this permit, or certificate shall invalidate it.
3. This permit or certificate shall be subject to the provisions of any law in force during the period of validity of the permit or certificate, in the area to which the permit or certificate to such person.
4. The holder of this permit or certificate shall, at the request of a person authorized in terms of the relevant legislation so to demand, forthwith produce such permit, or certificate to such person.
5. The holder of this permit or certificate shall return this original, permit or certificate to the Director: Wildlife Trade and Regulation, Limpopo Province, P.O. Box 55464, Polokwane, 0700.
6. This permit or certificate shall be invalid until the signature of the holder thereof has been appended thereto.
7. This permit or certificate shall lapse when it is lost or destroyed and no copy thereof shall be issued.
8. The holder of this permit, or certificate who contravenes or fails to comply with any one of the contravenes or fails to comply with any one of the conditions or requirements to which this permit or certificate is subject, shall be guilty of an offence.
9. An officer authorized thereto by the MEC may cancel this permit or certificate at any time.
10. This permit or certificate does not absolve the holder thereof from the necessity of obtaining such other permits and/or documents as may be required by law from the relevant, Dept., Provincial or Country.
11. This permit, or certificate stays the property of the Department.
12. An officer authorized thereto by the MEC may cancel, alter or change any general conditions and requirements of the permit or certificate or any special condition attached to the permit or certificate.
13. The holder of this permit or certificate will collect the original permit, or certificate from LEDET's offices where the application was lodged.
14. The holder of this permit or certificate will sign the permit, or certificate and a copy of the permit, or certificate will either be couriered, e-mailed, faxed or hand delivered back to the office where the permit, or certificate was issued from, within five (5) working days upon receipt of the original permit, or certificate.

SPECIAL CONDITIONS

THIS PERMIT MUST BE SIGNED BY THE PERMIT HOLDER AND MUST BE IN HIS/HER POSSESSION FOR THE DURATION OF THE PROJECT.
THE PROJECT LEADER MUST OBTAIN THE WRITTEN PERMISSION OF THE LANDOWNER ON WHOSE PROPERTY THE ANIMALS WILL BE COLLECTED PRIOR TO THE COLLECTION THEREOF.
THIS PERMIT ALSO AUTHORISES THE HOLDER THEREOF TO CONVEY WITHIN THE PROVINCE, OR EXPORT FROM THE PROVINCE THE COLLECTED SPECIES REFER TO ON THIS PERMIT, TO ANY OTHER PROVINCE WITHIN THE COUNTRY. SUCH ACTION WILL BE SUBJECT TO IMPORT PERMITS FROM SUCH PROVINCE.
COPIES OF PUBLICATIONS EMANATING FROM THIS RESEARCH PROJECT SHOULD ALSO BE FORWARDED TO THE ADDRESS STATED UNDER POINT 6.
A DATASHEET ACCORDING TO THE ATTACHED DATA FORMAT MUST BE COMPLETED FOR EACH SPECIMEN COLLECTED AND BE RETURNED TO THE BIODIVERSITY OFFICE FOR THE PROVINCIAL DATABASE PROJECT.
ALL REQUESTED INFORMATION OR ENQUIRIES MUST BE DIRECTED TO THE LIMPOPO ENVIRONMENTAL MANAGEMENT AUTHORITY, P.O. BOX 55464, POLOKWANE, 0700.

THIS PERMIT AUTHORIZES THE APPLICANT TO HARVEST HERBARIUM SPECIMEN OF THREATENED PLANTS.
ONLY HARVEST PARTS OF HERBACEOUS PLANTS (DO NOT UPROOT).
ONLY HARVEST FEW LEAVES, FRUITS AND FLOWERS OF ANY THREATENED PLANT.
FOR PLANTS WITH BULB IN POPULATION OF LESS THAN 15 DO NOT HARVEST ANY BUT CAN HARVEST 15 SHOOT PIECES.

CITES & PERMIT MANAGEMENT
ENVIRONMENTAL AFFAIRS

Appendix 3: Participant's consent form

I (the participant),……………………………………………………...(Full name (s) and surname) hereby to voluntarily offer participation in the doctoral research project titled: "*Threatened plant species in the Vhembe Biosphere Reserve, Limpopo province, South Africa: Problems and prospects of conservation and utilization".* I have read and understand all the information written on appendix one and Mr. Luambo Jeffrey Ramarumo have also unambiguously explained the aim and objectives of his study to me. I fully understand that my participation in this study is voluntary and that I can freely withdraw my participation at any time if I feel to do so, without being penalized. I am fully aware that this research project will be conducted in association with the University of Fort Hare Policy on Research Ethics.

Participant's signature:____________________signed at (place):___________________on the (day) of_________________________(month), the year 20____.

Researcher's names: Luambo Jeffrey Ramarumo, Signature: signed at (place):___________________on the_____(day) of________________(month), the year 20_____.

Witness's names___________________________nature:_______________signed at (place): on the (day) of____________________________________(month), the year 2018.

Participant's confidential information.

Residential address:……………………………………………………….

Cell number (if any):………………………………………………………..

WhatsApp number (if any):…………………………………………………

Email address (if any):………………………………………………………

Appendix 4: Non-disclosure consent of confidentiality

This non-disclosure and trade secrecy consent of confidentiality will be effective as on the (day) of______________________________________(month),________________________20 and is entered into, by the following parties:

1. Title:____Name (s) and surname: ___________________________________(Doctoral Student Researcher).

2. Title:_________________________________Name (s) and surname: (Custodian of the below non-disclosure knowledge or information).

Declaration to keep non-disclosure and trade secret information confidential:

I,_______________________________________, a Doctoral Student Researcher (Student No.) at the University of Fort Hare, hereby declare that I will respect the participants' wish regarding their non-disclosure information and confidentiality. I will treat the non-disclosure and trade secret information as fully confidential, only if requested to do so by the custodian of that particular knowledge or information. All non-disclosure and trade secret information will not form part of the findings in this study. Below is the list of non-disclosure and trade secret information:

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………

Signature (Doctoral student researcher):__________________________________signed at: (Place) on the_______________(day) of_________________________(month), 20____.

Signature (Custodian of the non-disclosure information):_________________________.signed at:____(Place) on the (day) of_______________(month) 20_____.

Appendix 5: Conflict of interest declaration

I, ____**(**Doctoral Student Researcher**),** of **Student No.______________________________,** Department of Botany, Faculty of Science and Agriculture, University of Fort Hare, investigating the research topic titled: "*Threatened plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa: Problems and prospects of conservation and utilization*", declared that I have no any other interests on the research topic to be investigated, except the partial fulfilment of the requirements for the Doctor of Philosophy (Ethnobotany).

Signature (Doctoral Student Researcher):______________date____.Month of_________ 20 .

Appendix 6: Research questionnaires

Threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa: Problems and prospects of conservation and utilization			
Interviewer's name:	Luambo J. Ramarumo (Doctoral student researcher)		
Institution:	University of Fort Hare		
Address:	Faculty of Science and Agriculture, Department of Botany, University of Fort Hare, Alice, 5700, South Africa		
Contact details:			
Survey date:		**Duration**	

Questionnaires

1. Socio-demographic information										
(a) Gender specificity	Male		Female		Other		If other, specify			
(b) How old are you (age in years)?	18 - 30		31 - 43		44 - 56		57 - 69		If other, specify	
(c) What is your marital status?	Unmarried		Married		Divorced		Widowed		If other, specify	
(d) Tell us about your employment details?	Unemployed		Employed		Self-employed				If other, specify	

(e) How do you make a living?	Salary		Stipend		Pension		Child-support grant							
	Disability-grant		Profit		Parental support		Old-age grant							
What is your average monthly income (ZAR)?														
(f) Tell us about your occupational details?														
(g) How long have been working as such (in years)?	1 - 2		3 - 4		5 - 6		7 - 8		9 - 10		11 - above	If othe, specify		
(h) Did you receive any form of staining for your profession?	Yes		No		If no, specify		If yes, what form of training did you receive	Forma l		Informa l				
(i) Share with us more about your educational background?	Not formally educated		Primary education		Secondary education		TVET/Collage education							
	TVET/Collage education		University education											
2. Indigenous knowledge system associated to threatened plant species utilization, distribution and conservation														
(a) Is there threatened or protected plant species in your dwelling area that you could recognise?	Yes		No											
(b) (i) If yes, what do you know about these plant species?		(iii) Tell us more about where they are distributed in this region?												

(c) Could you be able to identify these plant species in the field?		If yes, could you be able to accompany us to where they are distributed for identification and specimen collection purpose?	

(d) Mention all the threatened/ rare or plant species of conservation concern you knew or utilizes in the Vhembe Region?

Plant name	**Growth habit**	**Uses**	**Part used**

(e) For medicinal threatened plant species mentioned above, specify the ailment that they treat, preparatory methods and dosage and modes of administration?

Plant name	**Ailment that it treats**	**Preparation method**	**Mode of administration**

(f) How do you know about these useful	Knowledge gained from the		Friend		Famil		Parental knowledge	

threatened plants?	ancestors		s		y			
(g) Tell us more about the modes used while of gaining such knowledge?	Word of mouth		Dream and vision while asleep		Trained for it		If other, specify	

(h) How do you maintain the existence of these useful threatened plant species in this region?					
(i) What do you think could be done to sustain these species of conservation concern and why?					
(j) Is there anything you want to add about threatened plant species, their utilization and conservation?	Yes		No		
(k) If yes, feel free to add anything related to threatened plant utilization, conservation and distribution in the Vhembe Biosphere Reserve?					
(l) Tabulate any useful plant species that you know in the Vhembe Biosphere Reserve, Limpopo Province, South Africa?					

Plant species name	**Uses**	**Part used**	**Contribution to human development**

(j) What do you think and about indigenous conservation practices in the Vhembe region?

(k) Do you know any mechanism associated to indigenous conservation?	Yes		No		

(l) If yes, tabulate these mechanisms, as well as their efforts?	
Indigenous conservation strategies	**Their effort or aim**

(m)What are the ways of enforcing compliant compliance indigenous conservation mechanisms?
(n) Is there anything that you would want to add associated with indigenous conservation?

Appendix 7: Published research articles

BIODIVERSITAS
Volume 21, Number 5, May 2020
Pages: 2146-2158

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d210543

An inventory of useful threatened plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa

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Manuscript received: 10 April 2020. Revision accepted: 22 April 2020.

Abstract. *Ramarumo LJ, Maroyi A. 2020. An inventory of useful threatened plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa. Biodiversitas 21: 2146-2158.* Scientists and conservation managers are seeking to understand and monitor plant species that are likely to be on the verge of extinction risk. Monitoring of threatened plants' extinction risk can be better achieved through insights about indigenous knowledge dynamics associated with those species. This study aimed to document detailed information about useful threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. Data was collected through interviews with 203 participants and literally counting of individuals as per the IUCN's Red List Criteria. A total of 13 useful and native threatened plants belonging to 12 families were recorded. The majority of the threatened plant species were being used for medicinal purposes only (46.0%) followed by the mixture of medicinal and ornamentals (23.0%). The frequently cited useful threatened species with UV > 0.024, RFC > 0.059 and FL > 5.911%, includes *Asparagus sekukuniensis*, *Bowiea volubilis*, *Brackenridgea zanguebarica*, *Ocotea bullata*, *Rhynchosia vendae*, *Siphonochilus aethiopicus* and *Warburgia salutaris*. About 47.0% of the recorded useful threatened plants were distributed in remote areas of the Thathe Vondo and its surroundings. Threatened plants with the population size < 100 adult individuals constitute an overall of 61.54% of all the recorded species. The current study provides substantial information about useful threatened plant species in the studied region. Detailed information about threatened plant species remains fundamental for making informed decisions that are important for managing species of conservation concern.

Keywords: Distribution, population size, useful threatened plant species, utilization, Vhembe Biosphere Reserve

Abbreviations: FL: Fidelity level, IUCN: International Union for Conservation of Nature, RFL: Relative frequency of citations, UV: Use value

INTRODUCTION

Over the past decades, global conservation of threatened plant diversity has gradually increased and governments throughout the world have vowed to make the conservation of those plant species mandatory (Ma et al. 2013; Walsh et al. 2013; Pimm et al. 2014; Pimm and Joppa 2015; Heywood 2015; Rossi et al. 2016; Bailey et al. 2016; Dzerefos et al. 2017; Xu et al. 2017). Scientists and conservation managers around the globe are varying with regard to the predictions of extinction rates (Smith et al. 1993; Keith et al. 2008; De Vos et al. 2015; Ceballos et al. 2015). Lenzen et al. (2012) and Pimm et al. (2014), reiterated that the present rate of plant species extinction is roughly 1000 times than usual rates. However, Valiente-Banuet et al. (2015), argued that real and empirical extinction rate is likely to exceed the predicted rates. Climate change and human disturbance such as over-exploitation of plant resources, agricultural land expansion, development of new settlement, deforestation and afforestation of exotic plants for commercial are considered amongst the main drivers of habitat loss and species extinction (Bellard et al. 2016; Graham et al. 2016; Leitao et al. 2016; Brose et al. 2017; Ceballos et al. 2017).

Internationally, the mandates and authority for categorizing plants as threatened species are carried out by the International Union for Conservation of Nature (IUCN), whereas, in South Africa, those mandates are fostered by the South African National Biodiversity Institute (SANBI), an affiliate body of the IUCN (Moraswi et al. 2019). Threatened plant species refer to any species that have been evaluated using the International Union for Conservation of Nature (IUCN)'s version 3.1 of the Red List Categories and Criteria and therefore, categorized as either Vulnerable (VU), Endangered (EN) or Critical Endangered (CR) (IUCN 2012). Useful plants are defined as the species that are utilized by humans to fulfil their needs (Williams et al. 2013; Ramarumo et al. 2020). Threatened plants are protected internationally by treaties and conventions (Cock et al. 2010; de Oliveira et al. 2011). The United Nations Convention on Biological Diversity (CBD) gives particular relevance to the use of genetic resources and the associated traditional knowledge (Talaat 2013). The whole protocol is dedicated to the access of resources, fair and equitable sharing of benefits from their utilization (Buck and Hamilton 2011). In South Africa, the protection of threatened plant species is mandatory under various regulations, including the National Environmental Management: Biodiversity Act No. 10 of 2004, National Environmental Management Act No. 107 of 1999 and the Conservation of Agricultural Resources Act No. 43 of 1983

(Cousins et al. 2010; Badenhorst 2011; Bamigboye et al. 2017).

The Soutpansberg Region of the Vhembe Biosphere Reserve, in the Limpopo Province is considered one of the key biodiversity hotspot in South Africa (Kirchhof et al. 2010; Hahn 2017; Hahn 2019; Bamigboye and Tshisikhawe 2020), but there is a dearth of information about useful threatened plant species in this region. There are no doubts that some threatened plant species are extant and useful in this region. Yet, detailed information about their values to local peoples' livelihoods, population size, distribution range, and conservation status have not been comprehensively studied. Insights about useful threatened plant species could lead to the betterment of their management and policy-revision. Biró et al. (2014) uttered that indigenous knowledge associated with useful threatened plant species have not been comprehensively studied in South Africa and worldwide, whereas, Manne and Pimm (2001) argued that conservation managers, policy-makers and scientists are seeking to understand and monitor plant species that are likely to be on the verge of extinction risk. Therefore, better monitoring, management, and prediction of threatened plants' extinction risk can only be achieved through better insights about indigenous knowledge dynamics associated with those species (Von Glasenapp and Thornton 2011).

Insights about threatened plant species' use-values, population size, distribution range, and present conservation status could provide better understanding of conservation need required for individual taxon. The current study aimed to document detailed information about useful threatened plant species in the Soutpansberg Region of the Vhembe Biosphere Reserve, Limpopo Province, South Africa. Thus, this study could provide baseline data required for policy-revision, monitoring, management, and either assessment or re-assessment of extinction risk on threatened plant species within the region and countrywide.

MATERIALS AND METHODS

Study area

Topography and geology

The current study was, held in the Soutpansberg Site of the Vhembe Biosphere Reserve, in the Limpopo Province, South Africa (Figure 1). Some parts of the study site are within the conservation area called Soutpansberg Biodiversity and Endemism Centre (Mostert et al. 2008; Taylor et al. 2013). The study area is located in the far northern part of the Limpopo Province in South Africa. Its surface area is approximately 6700 km^2 (Hahn 2017), with an estimated population size of about 1 393 950 peoples in 2019, of which 98% of them are the black ethnic groups (Vhembe District Municipality 2019), whom, the majority (67.16%) of them speaks the Tshivenḓa language as their inborn language (Census 2011). This region is considered the getaway passage from South Africa to its neighboring countries that it shares the borders with, including Zimbabwe, Botswana, and Mozambique. The topographical zones of the study area range from 22º15′0" to 23º45′0" South latitudes and 29º0′00" to 31º0′0" East longitudes, whereas, its elevation lies from 200 to 1748 m above the sea level (Hahn 2017). The geological formation of the region resembles volcanic and sedimentary succession with features that include Wylies Poort geological formation of the Soutpansberg Group, Kalahari Cratons, Bushveld Igneas Complexity, Karoo System and the Limpopo Archaean Cratons (Barton et al. 2006; Hahn 2011).

Vegetation and climate

The Soutpansberg Region of the Vhembe Biosphere Reserve can be described by its diverse and incessant vegetation mosaic range from the Soutpanberg Mountain Bushveld with some patches of grasslands and Afromatane Forest within, to the Semi-desert scrubland (Luseba and Tshisikhawe 2013; Hahn 2017). Some of the dominant plant species found in the Soutpansberg Arid Region included, *Tribulus terrestris* L., *Grewia hexamita* Burret and *Terminalia prunioides* M.A. Lawson, whereas, the some dominant forest plant species include, *Xymalos monospora* (Harv.) Baill., *Kiggelaria africana* L. and *Rhoicissus tomentosa* (Lam.) Wild & R.B.Drumm (Mostert et al. 2008). Climatically, the Soutpansberg could be described by its seasonal variations in terms of rainfall and temperature. Usually, the Soutpansberg's average annual rainfalls range from 300 mm (Mpandeli 2014) in the winter season (spans from May to September) to 1874 mm (Hahn 2018) during the summer seasons (span from October to April). According to Hahn (2018), the average annual rainfall volume of the region diminished from the southern central regions where there is red-clay soil towards the northwestern site of the Soutpansberg. Generally, the regional annual temperatures range from 20ºC in winter to 30ºC during the summer season (Mostert et al. 2008).

Socio-demographic information

The total number of 203 participants took part in the current study, including laypeople (41.3%), traditional health practitioners (23.8%), farmers (9.9%), escorts for traditional health practitioners (16.2%), hunters (5.2%) and environmentalists (3.5%). Although the Soutpansberg has been labelled as one of special economic zones in South Africa, due to the availability of its underground coal reserves (Department of Trade and Industry 2017), its economic status still explicitly resembles poor reforms, with 90.8% of participants without tertiary educational qualifications. The unemployment rate > 53.9%, with the majority of people (57.5%) rely upon the government grants and parental support for livelihood and therefore, 58.9% of them seemed to earn an annual income of < US$ 2880 (Figure 2).

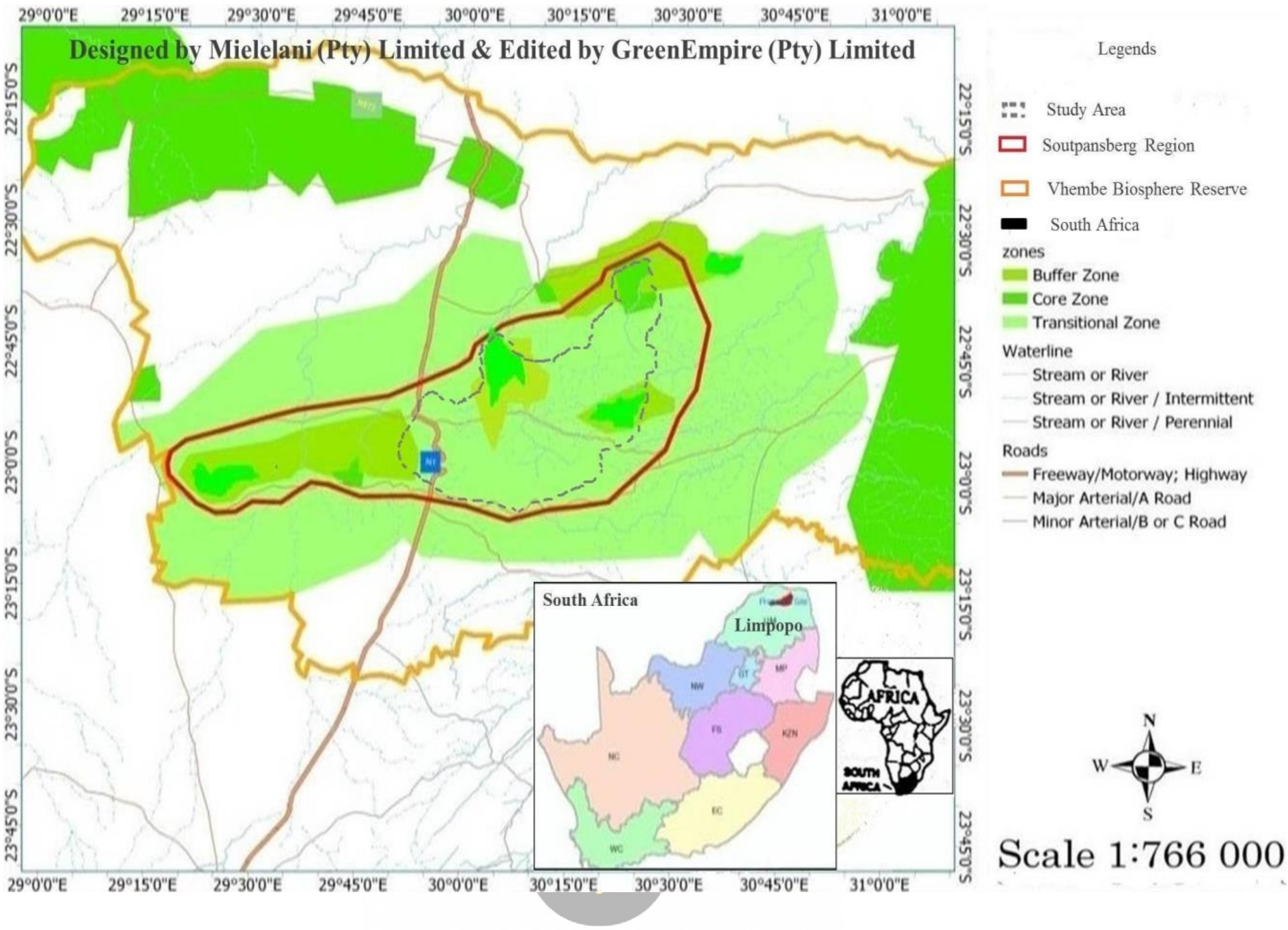

Figure 1. Locality map of the studied region in the Soutpansberg Site, Vhembe Biosphere Reserve, Limpopo Province, South Africa

Methods

Data gathering

Data collection was conducted over a period of 15 months, from August 2018 until October 2019. Information about useful threatened plant species in the Soutpansberg, Vhembe Biosphere Reserve, Limpopo Province in South Africa was acquired through Participatory Rural Appraisal (PRA) using semi-structured questionnaires in an interview with the total number of 203 individual participants (Figure 2). The small sample size or number of participants chosen was motivated by the duration taken during the interview (Flax et al. 2017). Participatory Rural Appraisal is considered an ideal research technique for exploration and documentation of information about useful natural resources (Chamber 1994; Weber and Ringold 2019) including threatened plant species. The University of Fort Hare's Research Ethics Committee reviewed the legitimacy of the current study and therefore, endorsed it with an Ethical Clearance Certificate of the reference number MAR031SRAM01, prior to the commencement of data collection. Pilot study was undertaken, prior to data sampling survey and its focus was to clearly explain the objectives of the study to all participants, testing the reliability of the questionnaires, and seeking permission to proceed with the current study from traditional leaders and private landowners. All the participants signed the written informed consent, stipulating that their participation could remain voluntary, they could freely quit participating at any time they wish, their acquittal could not penalize them in any way and their information could only be used for research purposes.

Participants were selected randomly during the community gathering and prior to them giving their informed consent. The randomly chosen participants included laypeople, traditional health practitioners, escorts for traditional health practitioners, farmers, hunters, and environmentalists, aged from 18 to 93 years old. The targeted recruits, involves both genders, with female participants constituting 58.3% and male 41.7% (Figure 2). To ensure confidentiality and smooth flow of information during the interview sessions, all participants were interviewed individually at their homesteads and therefore, all questionnaires were administered using the Tshivenḓa language, better understood by all people across the studied region. Furthermore, to ensure the high level of validity, authenticity, legitimacy, and veracity of the given responses by the recruits during the interview sessions, similar questions were posed to them all.

Data about threatened plants' population size across the studied region was gathered through literally counting of individuals per taxon. During sampling, only adult threatened plant individuals were targeted per taxon. This was influenced due to the fact that the IUCN‘s version 3.1 of the Red List Categories and Criteria stipulates that only adult individuals of species could be considered for the conservation status assessments (IUCN 2012). However, the current study was never intended to either assess or re-assess the conservation status of threatened plant species in the studied region, instead, it was all about documentation for detailed information associated with useful threatened plants, including their international and national conservation status, as well as their coordinates of location for their distribution range and also their population size across the studied region. To avoid the re-counts of species during population survey, coordinates of location for all the counted adult individuals of every taxon were recorded using Global Positioning System (GPS) Reader Application (Dead Duck Software, Version 4.0) on Samsung Galaxy J2 Core (Model number SM-J260F/DS). Data about either their international or national conservation status was gathered from the IUCN Red List of Threatened Species (Version 2019-2) database and South African National Biodiversity Institute (SANBI) Red List of South African Plants (Version 2017.1) database. Data associated with the distribution and locations for the threatened plant species within the studied region were also recorded using the GPS Reader Application on Samsung Galaxy J2 Core. This could simplify the monitoring of threatened plant species within the studied region in the future.

Specimen collections

Sampled data were then supplemented by a guided field-inspection survey led by the participants who seemed to be more familiar with the exact locations of the target plant species, for identification and voucher specimen collection purposes. In South Africa, threatened plant

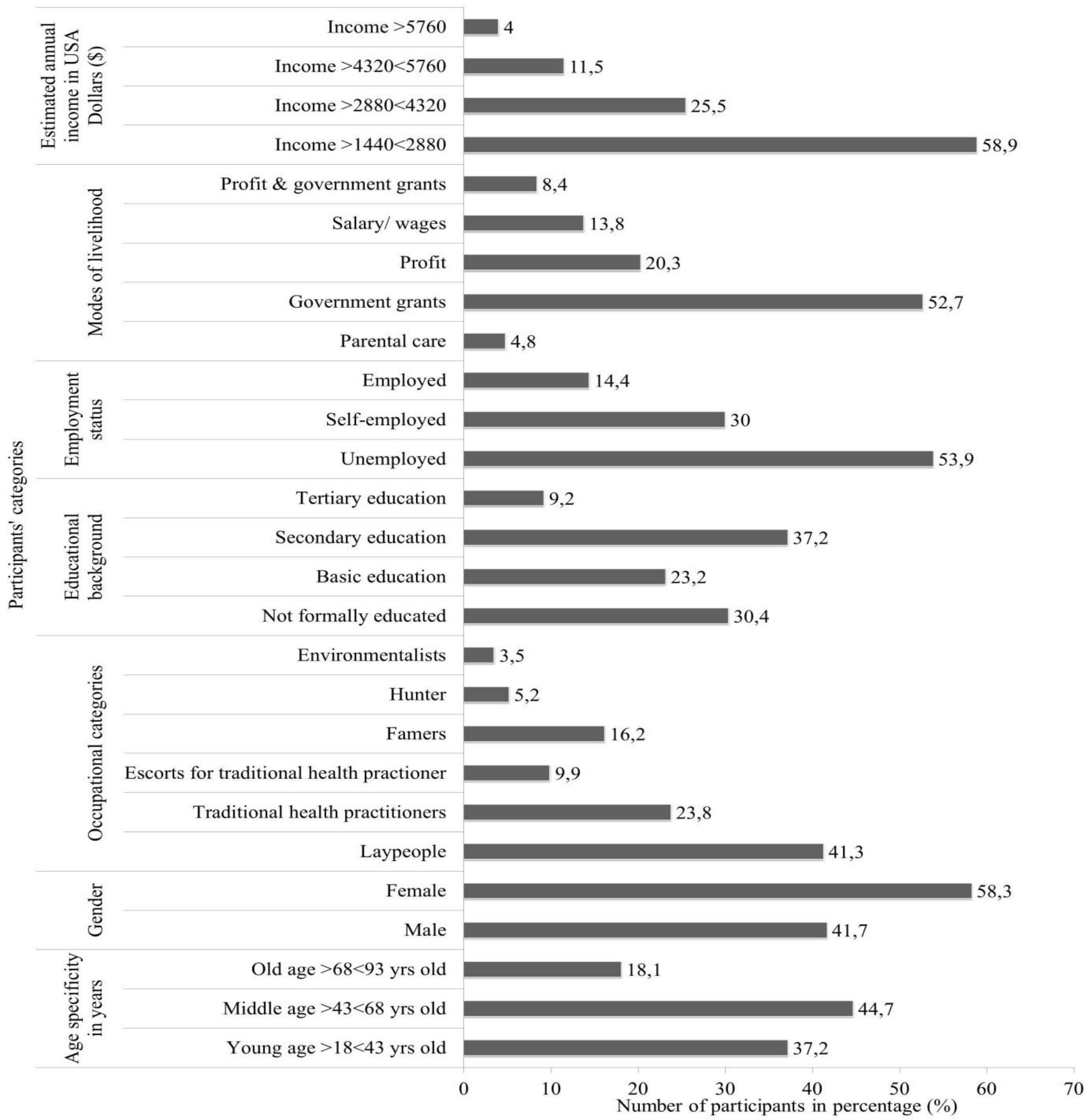

Figure 2. Participants' socio-demographic information

species collection is regulated under the National Environmental Management: Biodiversity Act, 10 of 2004 (NEMBA) (Molewa 2007; Crouch et al. 2008), therefore, voucher specimen collection permit No. ZA/LP/100948 (Reference No. CPM/30877/2019) was issued by the Limpopo Provincial Department of Economic Development, Environment, and Tourism (LEDET). At first, participants identified the target plant species using their vernacular names and then, their botanical names were later authentically verified by trained taxonomists. Furthermore, the collected specimens were then prepared (dried and mounted), assigned the voucher code, and deposited in Botany Herbarium of the University of Venda.

Data analysis

Data gathered through the PRA during the interview with participants were analyzed qualitatively, using three ethnobotanical indices such as the use value (UV), relative frequency of citations (RFC), and fidelity level percentage (FL%) (Atyosi et al. 2019). According to Al-Qur'an (2009) and Umair et al. (2017), UV indicates the relative importance regarding the utilization of the cited plant species, and it is determined using the following formula:

$$UV_i = \frac{\sum U_i}{N},$$

Wherein, the UV is considered to be the use-value of individual taxon, U: being the number of uses cited for that taxon and, therefore, N: represents the total number of recruits who cited the taxon (Phumthum et al. 2018; Shuaib et al. 2019). The relative frequency of citations (RFC), indicates local importance of every species within the studied region (Atyosi et al. 2019) and it is donated using the following formula:

$$RFC = \frac{FC}{N} \; (0 < \text{RFC} < 1),$$

Wherein, RFC, referred to the relative frequency of citations, FC: denotes the total number of the recruits who cited the uses of individual taxon and, N: being the total number of all the recruits who took part in the current study (Ahmed et al. 2014; Kankara et al. 2015; Hussain et al. 2018). Fidelity level (FL) refers to the percentage of recruits who cited the use of certain threatened taxon within the studied region and it was determined using the formula adopted from Singh et al. (2019):

$$FL(\%) = \frac{N_P}{N} \times 100,$$

Wherein, the FL (%), denote fidelity level of percentage, N_P: represents the number of recruits who cited the certain threatened taxon for the particular uses, whereas, N, denote the total number of recruits who cited the uses of any threatened taxon (Andrade-Cetto et al. 2011; Ullah et al. 2014).

RESULTS AND DISCUSSION

Conservation status

The results obtained in the present study demonstrated the existence of 13 useful threatened plant species in the Soutpansberg Site of the Vhembe Biosphere Reserve, Limpopo Province in South Africa. Although the current study was only focused on adult threatened plants, species like *Prunus africana* (Hook.f.) Kalkman seemed to be of poor regeneration since no seedling was observed within the studied region. According to Tesfaye et al. (2010) and Jimu et al. (2013), poor regeneration of *P. africana* could be possibly influenced by seed predation, lack of suitable habitat for seed germination, and human. Only five species within the recorded threatened plants seemed to have the IUCN conservation status (Year 2019), ranging from the IUCN Category, VU to EN, and therefore, all the 13 recorded species contain the SANBI conservation status (Year 2017), including VU, EN, and CR (Figure 3 and Table 1). The IUCN's conservation status of plants is considered important for enforcing the international laws, including treaties and conventions, whereas, SANBI's conservation status enforces the national regulations (Raustiala and Victor 1996; Raustiala 1997; Messer 2010; Trouwborst 2010; de Oliveira et al. 2011). This was not unusual since, Czech and Krausman (1997), and Possingham et al. (2002), reiterated that it has been a common understanding that threatened plant species are aligned with either national or international conservation status. The recorded species belonged to 12 families, including Apocynaceae, Asparagaceae, Canellaceae, Dioscoreaceae, Fabaceae, Hyacinthaceae, Lauraceae, Ochnaceae, Proteaceae, Rosaceae, Zamiaceae, and Zingiberaceae. Family Lauraceae contains two tree species, whereas, other families are represented by a single species (Table 1).

Moreover, family Lauraceae was only noticed in The Vonḓo site, which forms part of the Afromontane forest in the Soutpansberg (Table 2). This was common and literary, since literature studies suggest that tree species seemed to be more abundant in forests (Slik et al. 2015; Sun et al. 2017), rather in any biome. The diversity of threatened plant families reaffirms the evidence that indeed the Soutpansberg Site of the Vhembe Biosphere Reserve in the Limpopo Province, South Africa is a biodiversity hotspot (Küper et al. 2004; Reyers 2004; Clark et al. 2011; Moraswi et al. 2019; Hahn 2019; Bamigboye and Tshisikhawe 2020). In spite that some vernacular names cited by the participants were firstly recorded in the current study, all the recorded threatened plant species have their Tshivenḓa names and this demonstrates their local values. In the Soutpansberg Region, usually, the vernacular names for the folk medicinal plant species used by the Vhavenḓa ethnic group are associated with the name the ailments that they treat (Personal communication with all the recruits). For example, the Tshivenḓa vernacular name of the species *Ocotea bullata* (Burch.) Baill., is called Mulafhadali, and it means the malaria healer, with the prefix "Mulafha-", meaning the healer in Tshivenḓa language and the suffix "-dali", meaning the malarial infection. Maroyi and Van der Maesen (2013), affirmed that the vernacular names of plant species, implies their usefulness, since folk people hardly name plant species that they do not utilize.

Table 1. An inventory of threatened plant diversity in the Soutpansberg Site of the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Family	Botanical names and voucher number	Vernacular venda names	Habitus	IUCN Status (2019)	SANBI Status (2017)	Socio- values	Parts used	Same use citations	UV	RFC	FL (%)
Apocynaceae	*Huernia nouhuysii* I.Verd. (RAMLJ 021)	Tshiḓitshinzhi-tsha-Vhusendeka*	Succulent	-	VU	Birdlime-making	Latex	-	0.250	0.019	1.970
Asparagaceae	*Asparagus sekukuniensis* (Oberm.) Fellingham & N.L.Mey. (RAMLJ 013)	Lufhaladzamakole lwa thavha	Cactus	EN	EN	Medicinal	Whole plant	A	0.077	0.064	6.404
Canellaceae	*Warburgia salutaris* (G.Bertol.) Chiov. (RAMLJ 014)	Mulanga	Tree	EN	EN	Medicinal	Bark, leaves and root	B_1, B_2, B_3	0.0278	0.177	17.734
Dioscoreaceae	*Dioscorea sylvatica* Eckl. (RAMLJ 023)	Lurangatshiredzi*	Climber	VU	VU	Ethnoveterinary medicine	Bulb tuber	-	0.100	0.049	4.926
Fabaceae	*Rhynchosia vendae* C.H.Stirt. (RAMLJ 025)	Musivhamaṱo	Climber	-	VU	Medicinal and ornamentals	Whole plant	C	0.167	0.059	5.911
Hyacinthaceae	*Bowiea volubilis* Harv. *ex* Hook.f. subsp. *volubilis* (RAMLJ 015)	Nyalakhobvu	Climber	-	VU	Medicinal	Whole plant	D	0.077	0.064	6.404
Lauraceae	*Ocotea kenyensis* (Chiov.) Robyns & R.Wilczek (RAMLJ 026)	Mulafhadali*	Tree	VU	VU	Medicinal and timber	Bark, root and the leaves	E	0.067	0.059	5.911
Lauraceae	*Ocotea bullata* (Burch.) Baill. (RAMLJ 033)	Mulafhadali*	Tree	-	EN	Medicinal	Back and leaves	F_1, F_2	0.063	0.079	7.882
Ochnaceae	*Brackenridgea zanguebarica* Oliv. (RAMLJ 027)	Muṱavhatsindi	Tree	-	CR	Medicinal	Barks and root	D, G_1, G_2, G_3	0.024	0.202	20.197
Proteaceae	*Protea laetans* L.E.Davidson (RAMLJ 029)	Muphuphadzingu*	Shrub	VU	VU	Medicinal	Fruit and root	-	0.091	0.053	5.419
Rosaceae	*Prunus africana* (Hook.f.) Kalkman (RAMLJ 031)	Mulalamaanga	Tree	-	VU	Medicinal and timber	Bark and stem	D	0.182	0.053	5.419
Zamiaceae	*Encephalartos hirsutus* P.J.H.Hurter (RAMLJ 032)	Muvayambilana*	Cycad	-	CR	Medicinal and ornamentals	Whole plant	-	0.200	0.049	4.926
Zingiberaceae	*Siphonochilus aethiopicus* (Schweinf.) B.L.Burtt (RAMLJ 030)	Dzhinzhadaka*	Herb	-	CR	Medicinal and ornamental	Whole plant	H_1, H_2, H_3	0.143	0.069	6.897

Key notes: *: Vernacular Venda names that had never been recorded before, A: Ramarumo et al. (2019a), B_1: Maroyi (2014), B_2: Dludlu et al. (2017), B_3: Kunene and Masarirambi (2018), C: Magwede et al. (2019), D: Ramarumo et al. (2019b), E: Williams et al. (2013), F_1: Ogundajo et al. (2018), F_2: Ngubeni et al. (2017), G_1: Tiawoun et al. (2019), G_2: Tiawoun et al. (2018), G_3: Constant and Tshisikhawe (2018), H_1: Ullah et al. (2014), H_2: Fouche et al. (2013), H_3: Van Wyk (2015).

Table 2. Threatened plant species distribution, locations and observed threats across the Soutpansberg Region of the Vhembe Biosphere Reserve, Limpopo Province, South Africa

Plant species	Plant species location			No. of observed sites within the studied region	Observed threats
	Location	Coordinates of location			
		Latitudes	Longitudes		
Asparagus sekukuniensis	Muruṅwa	22º58′59.052" S	30º10′28.477" E	1	Habitat transformation due to human-settlement and recurring high-intensity fire man-made fire
Bowiea volubilis subsp. *volubilis*	Mauluma; Tshiṱavha, Matshavhawe and Vuvha	22º56′10.293" S; 22º57′57.953" S; 22º58′26.17 " S; 22º59′34.091 3" S	30º9′32.992" E; 30º11′27.225" E; 30º7′9.699" E; 30º10′59.016" E	4	Over-harvesting, invasion by alien plant species
Brackenridgea zanguebarica	Thengwe	22º40′22.325" S	30º34′22.659" E	1	Over-exploitation due high subsistence and commercial demand
Dioscorea sylvatica.	Tshifhire, Muruṅwa and Tshamaṱangwana	23º0′19.901" S; 22º59′26.002" S; 22º58′19.423" S	30º7′52.852" E; 30º9′24.623" E; 30º18′23.864" E	3	Habitat transformation due to new human-settlement development, invasion by alien plant species and over-harvesting
Encephalartos hirsutus	Muruṅwa and Vonḓo ḽa Thavha	22º59′46.154" S; 22º56′14.813" S	30º9′25.974" E; 30º21′8.15" E	2	Over-exploitation due to high commercial demand at both local and international markets
Huernia nouhuysii	ḒoliḒoli	22º42′15.742" S	30º10′26.554" E	1	Recurring drought, invasion by alien plant species and habitat transformation due to new human-settlement development
Ocotea bullata	Tshaṋowa Mountain, Thathe Vonḓo	22º56′18.719" S	30º21′8.373" E	1	Habitat fragmentation due to pine plantation
Ocotea kenyensis	Thethe Vonḓo Holy forest, and Tshamatingwane	22º53′6.374" S; 22º58′19.844" S	30º18′41.363" E; 30º18′15.879"E	2	Habitat fragmentation due to pine plantation
Protea laetans	Muruṅwa Mutshedzi and Muruṅwa Maramboni	22º58′14.937" S; 22º59′13.65" S	30º18′20.503" E; 30º8′59.46" E	2	Habitat transformation due to new human-settlement development, recurring high intensity man-made fire
Prunus africana	Khalavha, Tshiṱangani site and Thathe Vondo, Tshaṋowa Mountain Valley	22º55′5.956" S; 22º55′32.456 " S	30º18′24.894" E; 30º20′46.883"E	2	Habitat fragmentation due to pine plantation
Rhynchosia vendae	Makonde and Ha-Maelula	22º47′19.536" S; 22º59′9.146" S	30º33′47.509" E; 30º8′51.234" E	2	Invasion by alien plant species and habitat transformation due to new human-settlement development
Siphonochilus aethiopicus	Thathe Vondo, Tshamaṱingwane	22º58′11.676" S	30º18′17.197" E	1	Over-exploitation
Warburgia salutaris	Ha-Matsa	22º50′36.922" S	29º59′50.107" E	1	Over-exploitation due to commercial demand in local market

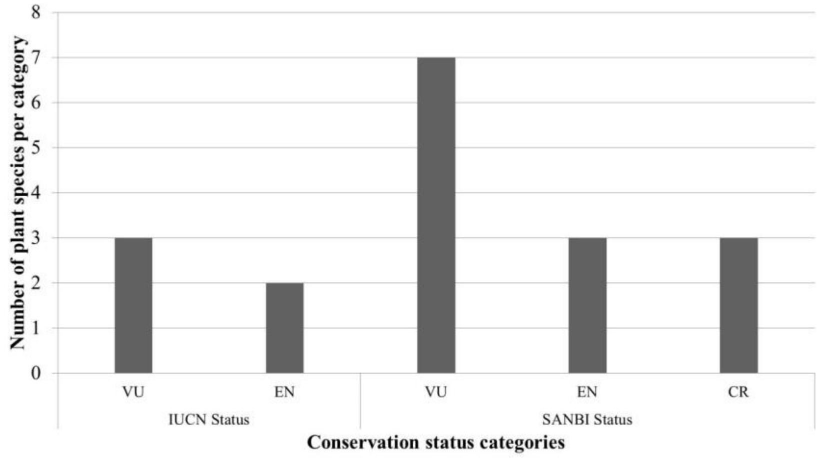

Figure 3. The number of international and national Red Listed threatened plant diversity

The frequently cited useful threatened plant species with UV > 0.024, RFC > 0.059 and FL > 5.911% included *A. sekukuniensis*, *B. volubilis* subsp. *volubilis*, *B. zanguebarica*, *O. bullata*, *R. vendae*, *S. aethiopicus*, and *W. salutaris* (Table 1). The UV, of threatened plant species, was pivotal for evaluating the most useful species as compared to their counterparts in the same sample (Umair et al. 2017; Setshego et al. 2020). The RFC is the summation of the threatened plants' reported uses based on participants citations for certain species without considering the use categories (Kankara et al. 2015; Mwinga et al. 2019). The FL value is used for evaluating the level of significance of the useful threatened plant species within the studied region shows the proportion between the number of participants who claimed the use of threatened plants for similar significant purpose and all participants who cited those plants for any other purpose (Khan et al. 2014; Tuttolomondo et al. 2014; Kayani et al. 2015; Dembélé et al. 2015).

Moreover, the aforementioned ethnobotanical induces (UV, RFL and FL) were strategically used for identifying the most significant and useful threatened plant species within the studied region (Farooq 2019; Atyosi et al 2019). Despite the availability of good and well-established regulations to help preserve, protect and restrict utilization of threatened plant species in South Africa (Foden 2007), *W. salutaris* and *B. zanguebarica* seemed to be frequently utilized by local people within the studied region and their FL values range from 17.734% to 20.197%. The results in current study illustrated local people utilizing *W. salutaris* and *B. zanguebarica* for none, but medicinal purposes only (Table 1). Although, this study lacks phytochemical and pharmacological evaluations, Mothupi (2014) and Ramarumo et al. (2019c), reiterated that African people in poor and marginalized communities usually utilized herbal medicines due to their therapeutic efficacy, viability, and reliability. Kurande et al. (2013), considered utilization and administration of herbal medicines in aboriginal cultural communities as completely experimental, whereas, Tengö et al. (2014), reported that traditional healing mechanisms required no validation of its phytochemical constituents, since it is trustworthy and it has been validated long-time ago through trial-error-experiments. Moreover, this study is, therefore, argued that high FL (%) value of *W. salutaris* and *B. zanguebarica* delineates that folk knowledge associated with those species is common and well-known to the majority of dwellers within the studied region. Literary to the study done by Tshisikhawe et al. (2013), over-harvesting of such an important plant species could eventually lead to the deterioration of their population structure and conservation status. According to Schatz (2009), a decline in the number of useful threatened plant species could also negatively impact the livelihood chain and the provision of traditional health care in rural and marginalized communities.

Local people within the studied region were found utilizing various threatened plant species for various purposes, depending on their growth habits and partly used (Figure 4). This includes utilizing those species for medicinal purposes (46.0%), medicinal and ornamentals (23.0%), medicinal and timber (15.0%), ethnoveterinary medicine (8.0%), birdlime-making and ornamentals both constitute (8.0%) (Figure 4A). Gosling et al. (2017) and Magwede et al. (2019) elucidated that local people in the Southern African Region, utilizes various plant resources for their various livelihood needs (Michler et al. 2019). Tree (38.0%) and climbers (23.0) seemed to be the most preferred habitus, whereas, frequently utilized parts were whole plant (38.0%), followed by the combination of bark, leaves, and root (15.0%) (Figure 4B and C). This was not unusual, since the study done by Leshabana and Tshisikhawe (2017) reaffirmed trees as the most preferred utilized plant habit. It is worth indicating that local people in the Soutpansberg Site of the Vhembe Biosphere Reserve in the Limpopo Province, South Africa have adopted their own and diverse livelihood strategies that include, frequent utilization of plant forms that have multi-useable parts and long life span (Sekgobela BF 2019, pers. com.; Siobo ZJ

2019, pers. com.; Muthivhithi KD 2019, pers. com.). According to Kunwar et al. (2010), local people in rural and marginalized remote communities usually develop various livelihood strategies that suit their needs. Therefore, the frequent utilization of tree species within the studied region was influenced due to their multiple usages and long life span. Although the results of the present study seemed to be in accordance with other studies in the region (Rampedi and Olivier 2013; Muhali 2017; Tshisikhawe and Malunga 2017; Ndhlovu et al. 2019), it is worthy to argue that over-harvesting of threatened plant species could cause a decline in their population size and eventually rapid extinction.

Distribution and population

More than 53.0% of the recorded useful threatened plant species are likely distributed in one location across the studied region. Although SANBI, an affiliate to IUCN considered the vegetation status of the Thathe Vondo as vulnerable (Munyati and Sinthumule 2014) with some little patches of pristine ecosystems within, the results in the present study delineate that about 47.0% of the recorded useful threatened plant species were distributed in the remote areas of the Thathe Vonḓo and its surroundings. This was due to the fact that threatened plants are considered sensitive to climate change, and therefore, remote and high elevation areas create a suitable micro-climate for their survival (Telwala et al. 2013). Since more threatened plant taxon was recorded in high elevation areas, the present study argued that threatened plant species richness in the Soutansberg Site of the Vhembe Biosphere Reserve in the Limpopo Province, South Africa, increased with an increase in elevation, annual rainfall and habitat viability. This was endorsed by both local and international scholars (Lobo et al. 2001; Vetaas and Grytnes 2002; Bruun et al. 2006; Munyati and Sinthumule 2014). The coordinates of locations for all the recorded useful threatened plant species range between 22º40′22.325" to 23º0′42.505" South latitudes and 29º59′50.107" to 30º33′47.509" East longitudes (Table 2). This can strengthen future monitoring of threatened plant species in the region. Whittaker et al. (2005) uttered that spatial information, including the use of GPS coordinates play an important role in modern conservation and monitoring. Table 2 shows that threatened plant species within the studied region are mostly threatened due to various threats regimes, including, habitat transformation, habitat fragmentation, over-harvesting, and invasion. Literature studies reaffirmed that invasion, over-exploitation of botanical resources, agricultural expansion, and habitat transformation are major cause of extinction risk (Du Toit et al. 2016; Heinrichs et al. 2016; Boon et al. 2016; Leroux et al. 2017; De Kort et al. 2018).

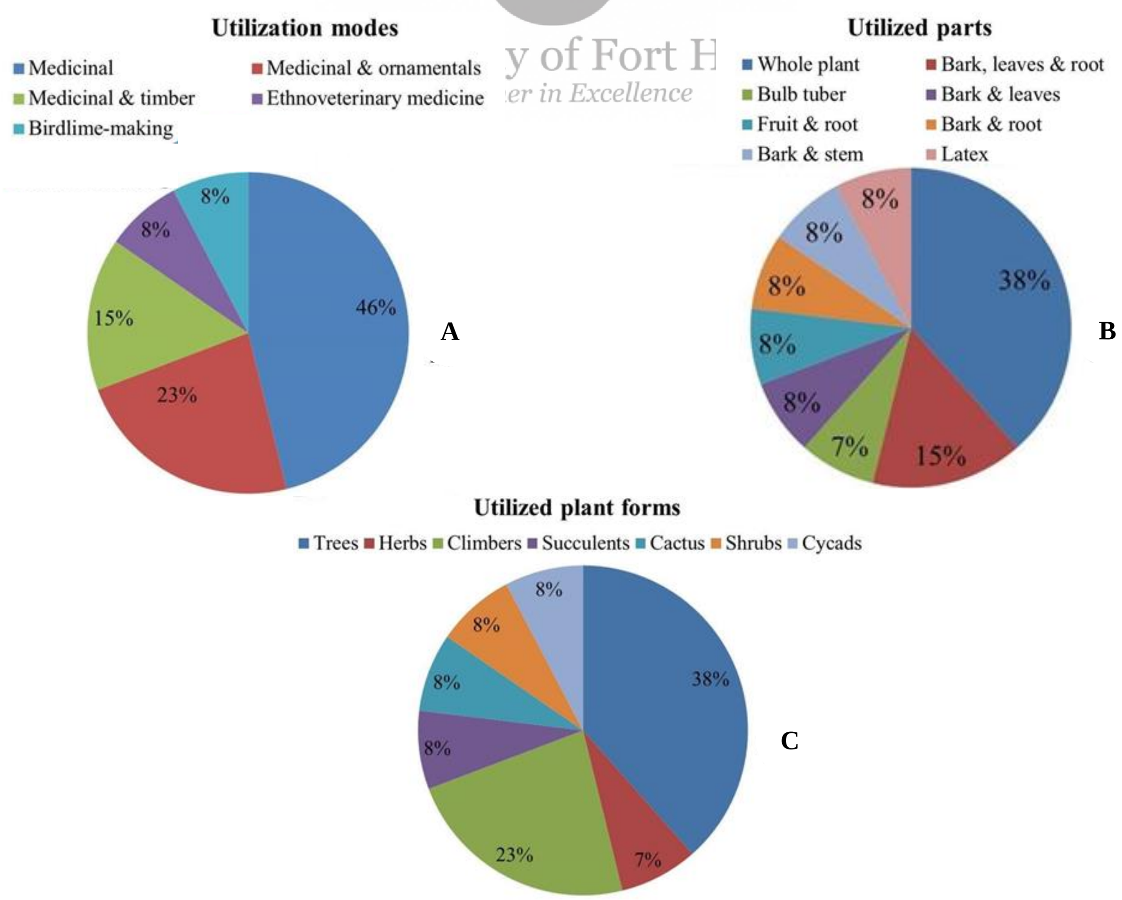

Figure 4. Utilization of threatened plant diversity

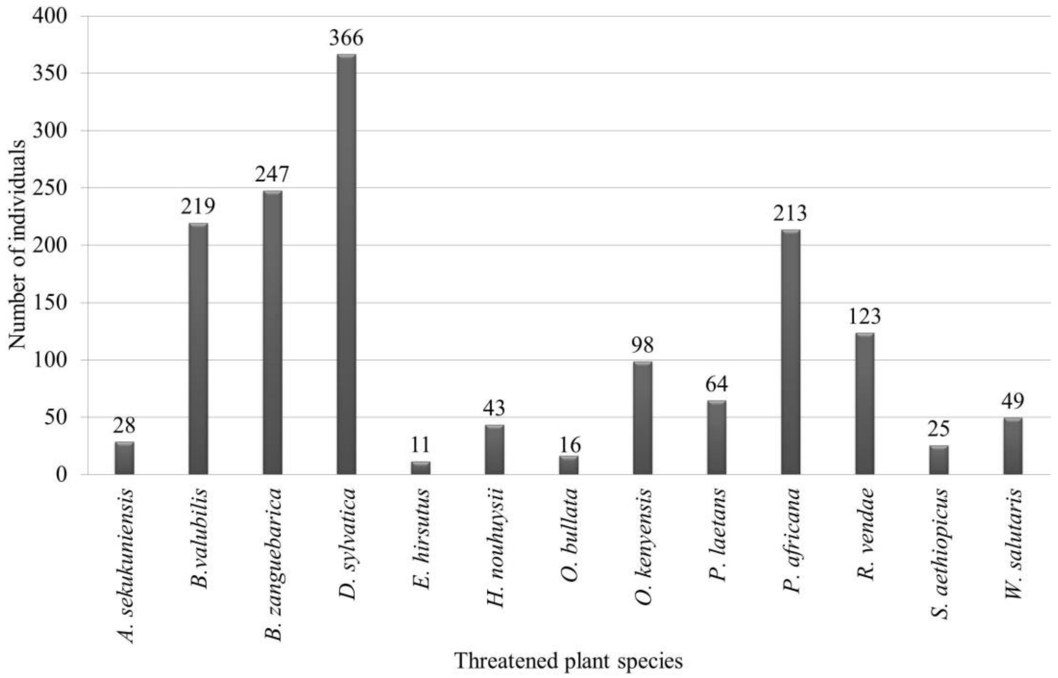

Figure 5. Number of adults threatened plants individuals within the studied region

Data about the population size of adult threatened plant species is considered crucial for either upgrading or downgrading the conservation status of the species, using version 3.1 of the IUCN 's Red List Categories and Criteria (IUCN 2012; Williams et al. 2013). Although the population size of adult *D. sylvatica* seemed to be over 300 individuals with various distributional ranges as compared to its counterparts (Figure 5 and Table 2), it still remains vulnerable to extinction since its combined area of occupancy within the studied region is approximately < 500 m^2. Presently the distribution range of *D. sylvatica* in the studied region is restricted to three small remote areas called Tshifhire, Muruṅwa, and Tshamaţangwana (Table 2). Although the conservation status of this species is only recognized nationally (Figure 3 and Table 1), the Categories and Criteria of the IUCN's Red List suggests that small distribution range, area of occupancy and other ecological aspects, implies that the species is on the verge of extinction risk (IUCN 2012). The results of this study showed threatened plant species with a population size < 100 adult individuals constituting an overall of 61.54% (Figure 5). Among them, there were, *P. laetans*, *O. kenyensis*, *O. bullata*, *A. sekukuniensis*. *W. salutaris*, *H. nouhuysii*, *E. hirsutus* and *S. aethiopicus* (Figure 5). This study argued that the smaller the population size of individuals of threatened plants in a single area of occupancy, the more vulnerable towards the verge of extinction they become. *Brackenridgea zanguebarica* is considered Critical Endangered in South Africa and its distribution range is restricted to a single geographic area or area of occupancy called Thengwe (Tiawoun et al. 2019).

The current study provides substantial information about useful threatened plant species, their distribution range and values linked to the improvement of local livelihoods and development. Detailed information about threatened plant species remains fundamental for making informed decisions that are important for managing species of conservation concern. In the Vhembe Biosphere Reserve, Limpopo Province, South Africa, local people do not perceive the values derived from threatened plant species as separate from their desire to improve their own livelihoods and daily strive for civilization. Therefore, the present study argued that insights about the dynamics surrounding threatened plant species in context with their utilization, population size, distribution range, and conservation status, are fundamental to encourage species-specificity monitoring and management plans. To the best of our knowledge, no study of this nature has been done before in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. In spite of all the restrictions that prohibit the use of threatened plant species in South Africa, local people in the studied areas perceived subsistence utilization of such plants as an integral part of their inherent heritage. This study has significantly demonstrated utilization of threatened plant species in the Vhembe Biosphere Reserve, Limpopo Province, South Africa. Although the utilization of threatened plant species seemed to be pivotal for the improvement of local livelihoods in the region, this study, therefore, recommended the re-evaluation of the conservation status of highly utilized species within the studied region.

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PLANT SPECIES USED FOR BIRDLIME-MAKING IN SOUTH AFRICA

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Keywords: Birdlime-making plants, Indigenous knowledge, Soutpansberg, Vhavenda people, Vhembe Biosphere Reserve

Abstract

Plants used for making birdlime and indigenous knowledge associated with the practice in Soutpansberg region, Vhembe Biosphere Reserve, Limpopo province, South Africa have been documented. Twelve birdlime-making plant species belonging to Apocynaceae, Celastraceae, Euphorbiaceae, Loranthaceae, Moraceae and Sapotaceae families were recorded. The common species included *Maytenus peduncularis* (Sond.) Loyes cited by 23.6% informants, *Euphorbia pulvinata* Marloth (17.2%) and *Landolphia kirkii* Dyer (12%). Plant parts used were latex (50%), fruit (34%), root (8) and the mixture of latex and fruit (8%). Documentation of plant species used for birdlime-making is of great interest, not only for preservation of the Vhavenḓa's traditional culture, but also for promoting economic subsistence, nutritional value and livelihood amongst poor and marginalized people.

Introduction

Indigenous knowledge about plant uses and processing is considered to be prevailing, adaptive, accumulative and dynamic (Dold and Cocks 2000). This wealth of knowledge presents crucial economic opportunities and transformation to the rural and marginalized communities across the globe (Siyanbola *et al.* 2012). More than 70% of populations in developing countries across the globe, rely on plant derived resources for their livelihoods and economic development (Maroyi 2011), including birdlime-making, medicinal and socio-cultural activities.

Birdlime refers to the adhesive and sticky substance derived from various plant materials used for trapping small birds (Tarugarira 2012). It is usually derived from latex of various plant species (Platt *et al.* 2012). Birds trapping is mostly done to address challenges such as livelihood, subsistence, medicinal and religious purposes (Imchen and Joglekar 2015). In many aboriginal cultural communities, the culture of birdliming serves as an important source of nutritional value (Belda *et al.* 2012). Birdliming activities are also considered to be widespread practices, especially in aboriginal cultural communities (McCulloch *et al.* 1992). Making of birdlime has been a fundamental part of traditional culture for the Vhavenḓa people for many decades.

As like in any other tribes across the African continent, the Vhavenḓa tribe mainly acquired their knowledge about birdlime-making plant species orally, through the word of mouth and cultural transmission from one generation or lineage to another (Tolossa *et al.* 2013). Despite different lifestyles lead by rural South Africans, local people in the Soutpansberg region still use birdlime as part of their traditional culture. There is a need to document and disseminate African biodiversity as this is a fundamental source of livelihood and cultural development (Pakia *et al.* 2003). But there is a dearth of information on diversity, uses and conservation status of Soutpansberg biodiversity. Most research done so far on Soutpansberg biodiversity focused on

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medicinal plant species and their phytochemical properties used as herbal medicines (Mulaudzi *et al.* 2011, Magwede *et al*. 2014). However, there was no direct study focused on plant species used for birdlime-making in that region. The current study, therefore documented plants used for making birdlime and the indigenous knowledge associated with the practice in Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa. The information about birdlime-making plant species is of great interest, not only for the preservation of cultural traditions (Belda *et al.* 2010), but also for the promotion of economic subsistence and nutritional value among poor and marginalized people.

Materials and Methods

The current study was undertaken in Kutama-Sinthumule and Nzhelele villages, in Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa (Fig. 1). Kutama-Sinthumule is located in the western region of the Makhado local municipality within the coordinates ranging from 23º5´0.065" to 23º7´29.712"S, 29º39´58.989" to 29º 48´ 44.614"E whereas, the Nzhelele region is located on the eastern side of the same local municipality and its coordinates ranging from 22º52´43.006" to 22º55´32.995"S, 30º3´28.285" to 30º16´53.212"E (Fig. 1).

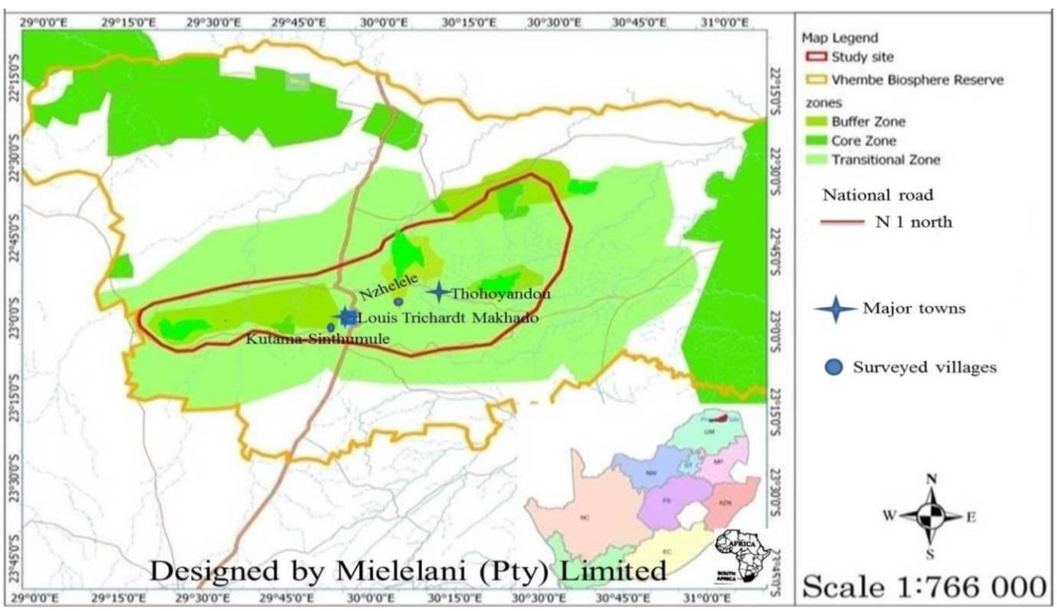

Fig. 1. Locality map of Soutpansberg.

The vegetation type within the study area is classified as bushveld of the savanna biome (Luseba and Tshisikhawe 2013). The climatic conditions of the study areas are characterized by warm-wet summer season (span from October to April) and mild-dry winter (May to September) (Gumbo *et al.* 2016). The regional mean annual rainfall ranged from 300 to 820 mm (Mpandeli 2014), with the highest rainfall received in summer season, while less rainfall is received during the winter season. The regional average annual temperatures range from 20 to 30ºC, with the highest temperature recorded in summer season (Mzezewa and Rensburg 2011).

Documentation of birdlime-making plant species used by the Vhavenda people in the Soutpansberg region was done through participatory rural appraisal (Chambers 1994), with the informants. This study was carried out in May, 2018 until the end of September, 2018. A total of 250 informants of various age groups were arbitrarily selected. Amongst the selected informants, there were 117 laypeople, subsistence farmers (50), herbalists (30), avifaunal hunters (34) and traditional healers (19) (Fig. 2).

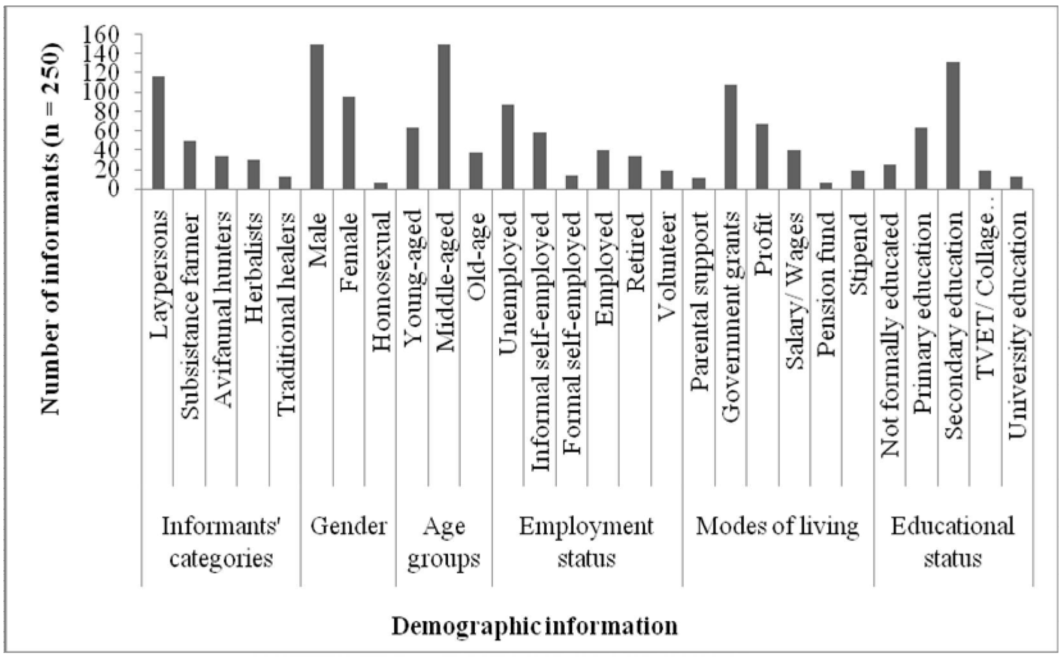

Fig. 2. Informants' biographical information.

All informants signed an informed consent form for participating in the current study, which was permitted by the University of Fort Hare Research Ethics Committee, reference number MAR031SRAM01. Information about the identities of birdlime-making plant species and traditional knowledge associated with the practice were obtained during the interview sessions with the informants using semi-structured and close-ended questionnaires (Mueller *et al.* 2010). To enhance the flow of ideas and participation confidence amongst the informants, interviews were carried out using local language of instruction (Tshivenda language). To avoid inconsistency and discrepancy in the administered questionnaires during the interview sessions, similar questions were administered to every informant. Field work was conducted to collect voucher specimens and validate the identities of plant species mentioned by the informants during interview sessions. The voucher collection permit was obtained from the Limpopo Department of Economic Development, Environment and Tourism, permit number: ZA/LP/92932. Data analysis was performed using Microsoft Office 2010 spreadsheet, descriptive statistical components such as, frequency of occurrence and percentage.

Results and Discussion

The total number of 12 birdlime-making plants belonging to 5 families were recorded. According to informants, the use of various plant species in the birdlime-making has been part of the Vhavenda people's indigenous conservation strategy to reduce harvesting pressure among useful species (Personnel communication with informants). This seemed to be certain since literature suggested that ethnobotanical use of diverse plant species demonstrates wisdom, dynamism and alternatives (Kunwar *et al.* 2015). Amongst the recorded families, Ephorbiaceae and Loranthaceae were the most frequently utilized families with 4 species each (Fig. 3). The frequent utilization of family Euphorbiaceae and Laranthaceae was underpinned due to factors such as distribution, species diversity within these families and their abundance in the study areas. Previous studies reported that Euphorbiaceae is a diverse and largest family within the flowering

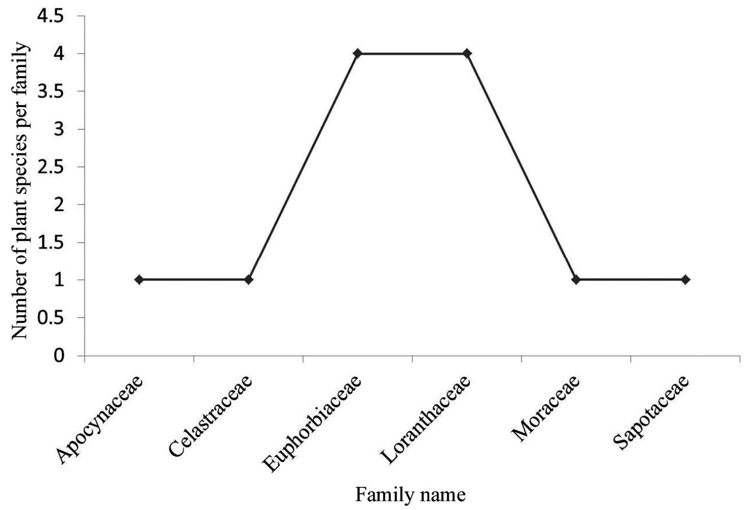

Fig. 3. Frequency of birdlime-making plant species per family.

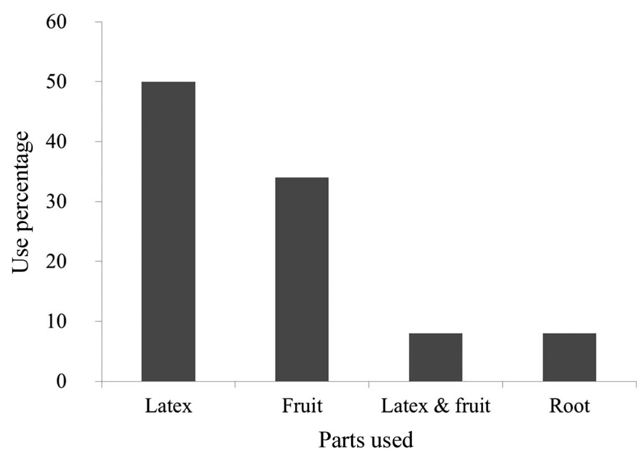

Fig. 4. Parts utilized.

Table 1. Inventory of birdlime-making plant species used by the Vhavenḓa people in the Soutpansberg, Vhembe Biosphere Reserve, Limpopo province, South Africa.

Family	Species	Vernacular name	Habit	Use	Parts	Preparation mode	Informants % level (n=250)	No. of same use citations	Voucher no.
Apocynaceae	*Landolphia kirkii* Dyer *ex* Hook.f.	Muvhungo (V), Rubber Vine (E)	Climber	BL	L& Fr	Latex is blown by air for about 30 minutes and the ripe fruit coat is crushed	12.0	4 (ABCD)	RAMLJ001
Celastraceae	*Maytenus peduncularis* (Sond.) Loes	Mukwatule (V), Indigenous Blackwood (E)	Tree	BL	R	Fresh root bark crushed or chewed	23.6	2 (AB)	RAMLJ002
Euphorbiaceae	*Euphorbia pulvinata* Marloth	Tshiḓitshinzhi (V), Pincushion Cactus (E)	Succulent	BL	L	Stirred while boiling for about 20 to 30 minutes	17.2	Non	RAMLJ003
Euphorbiaceae	*Synadenium cupulare* (Bioss.) L.C. Wheeler	Muswoswo (V), Crying tree (E)	Shrub	BL	L	Stirred while boiling in an opened space for about 30 to 45 min	3.6	1 (D)	RAMLJ004
Euphorbiaceae	*Euphorbia ingens* E.Mey. *ex* Boiss	Mukonde (V), Candelabra Tree (E)	Succulent	BL	L	Stirred while boiling in an opened space for about 30 to 45 min	2.0	2 (AB)	RAMLJ005
Euphorbiaceae	*Euphorbia tirucalli* L.	Muṱungu (V), Rubber tree (E)	Tree	BL	L	Stirred while boiling in an opened space for about 30 to 45 min	0.8	Non	RAMLJ006
Loranthaceae	*Erianthemum dregei* (Eckl. & Zeyh.) Tiegh	Tshilungwane (V), mistletoe (E)	Shrub	BL	Fr	Ripe fruits, crushed or chewed	8.8	2 (AB)	RAMLJ007
Loranthaceae	*Erianthemum ngamicum* (Sprague) Danser	Tshilungwane (V), Okavango mistletoe (E)	"	BL	Fr	Ripe fruits, crushed or chewed	7.2	Non	RAMLJ008
Loranthaceae	*Tapinanthus forbesii* (Sprague) Wiens	Makhuluwatshilungwane (V)	"	BL	Fr	Ripe fruits, crushed or chewed	8.0	Non	RAMLJ009
Loranthaceae	*Tapinanthus rubromarginatus* (Engl.) Danser.	Makhuluwatshilungwane (V), red mistletoe (E)	"	BL	Fr	Ripe fruits, crushed or chewed	7.2	Non	RAMLJ010
Moraceae	*Ficus thonningii* Blume	Moumo (V), common wild fig (E)	Tree	BL	L	Blown by air for an hour and more	6.0	2 (BF)	RAMLJ011
Sapotaceae	*Englerophytum magalismontanum* (Sond.) T.D.Penn.	Munombelo (V), milkplum (E)	Tree	BL	L	Blown by air for an hour and more	3.6	Non	RAMLJ012

A = Mabogo (1990), B = Magwede *et al.* (2019), BL = Birdlime, C = Constant and Tshisikhawe (2018), D = Pakia *et al.* (2003), F = Platt *et al.* (2012), L = Latex, L & Fr = Latex and fruits, Fr = Fruits, E = English name and V = Venda name).

plants and it contained over 2000 species (Ernst *et al.* 2015), whereas, family Loranthaceae is considered to have 950 species and 77 genera (Didier *et al.* 2009). Among the recorded species, 6 of them were reported for being used in the birdlime-making for the first time and this included *E. pulvinata* (17.2%), followed by *T. forbesii* (8%), *T. rubromarginatus* (7.2%), *E. ngamicum* (7.2%), *E. magalismon-tanum* (3.6%) and *E. tirucalli* (0.8%) (Table 1). High percentage level of informants who cited *M. peduncularis*, *E. pulvinata* and *L. kirkii* demonstrated the certainty of common knowledge associated with their uses in the study areas (Table 1). According to the informants, it is commonly known that birdlime derived from either *M. peduncularis* or *E. pulvinata* considered to be lasting, reliable and strong if subjected to the strengthening process using latex of *L. kirkii* (Personal communication). This was supported by Magwede *et al.* (2018), who demonstrated that *L. kirkii* plays a pivotal role in the birdlime strengthening. Fig. 4, represents the utilized parts of various birdlime-making plant species. Among these plant parts, latex was regularly utilized (50%), followed by fruit (34%), root (8%) and the combinations of latex and fruit (8) were equally utilized. The results of this study confoirm to the study done by Pakia *et al.* (2003). Although, indigenous knowledge about birdlime-making plant species seemed to be prevalent across the study areas (Fig. 5), instant transmogrified lifestyle tends to gradually erode this precious knowledge unnoticed. Mokganya *et al.* (2018), stated that urbanization and change in rural lifestyle can gradually erode local knowledge and traditional culture. Avifaunal hunters tend to have extensive knowledge of plants used for birdlime-making (Fig. 5). These results differ from the study done by Kayani *et al.* (2014), whereby laypeople were reported to have extensive knowledge about plant uses.

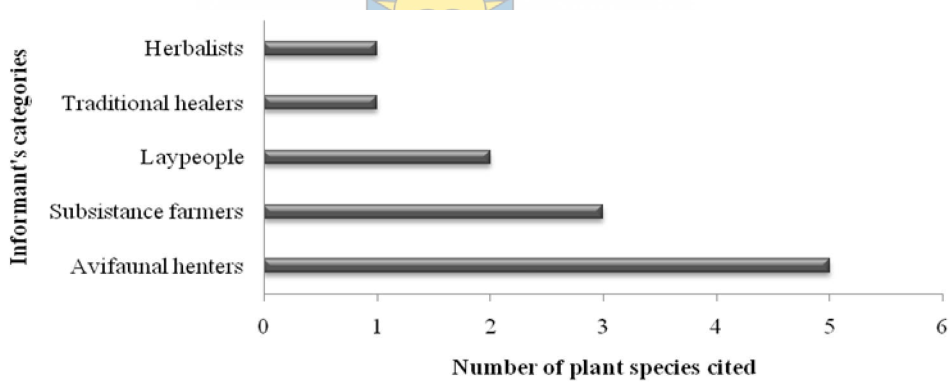

Fig. 5. Number of plant species cited per informant category.

The documentation of plant species used for birdlime-making is of great interest, not only for the preservation of traditional culture, but also for promoting economic subsistence, nutritional value and livelihood amongst poor and marginalized people. Plant species used by the Vhavenḓa people for making birdlime in Soutpansberg rRegion, Vhembe Biosphere Reserve, Limpopo province, South Africa yet to be fully understood. This study focused on documenting plant species used for birdlime-making by the Vhavenḓa people only, leaving the nutritional value and economic implications derived from birdlime-making untapped. Therefore, further studies about rural nutritional value and economic implications derived from birdliming practice are warranted. This could bring many rural communities countrywide and across the globe to the spotlight to completely understand the benefits derived from birdliming practice.

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Asparagus sekukuniensis (Oberm.) Fellingham & N.L.Mey.: A threatened medicinal plant species used by Vhavenḓa in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa

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ABSTRACT

Asparagus sekukuniensis is at risk of extinction in South Africa due to over-collection as herbal medicine. However, there is a scant of literature on the diseases cured by the species, parts used, dosage, and how it is administered. Therefore, this study was aimed at documenting ethnomedicinal uses of *A. sekukuniensis*, in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa. Data on ethnomedicinal uses of *A. sekukuniensis* were gathered with an aid of semi-structured dialogues, observations, and guided field walk by 125 participants between May and December 2018. Among the participants, laypeople were 35.2% and subsistence farmers were 14.4%. Specialist herbal healers include child health-care healers (29.6%), wound healers (11.2%), and general healers (9.6%). The recorded uses of *A. sekukuniensis* include the enhancement of fontanelle closure in an infant (24.8%), convulsions in an infant (22.4%), vaccinating epilepsy in an infant (17.6%), unhealed or cancer-related wounds (15.2%), genital wounds (12.0%), and boils (8.0%). *Asparagus sekukuniensis* appeared to be an important herbal medicine against infant ailments, wounds, infections, and infestations. These findings, therefore, call for an evaluation of the phytochemical and pharmacological properties of this species.

INTRODUCTION

Local people throughout the world have been using medicinal plants to maintain their well-being since time immemorial (Fabricant and Farnsworth, 2001; Falah and Hadiwibowo, 2017; Lulekal *et al*., 2013; Manzo *et al*., 2017; Saive *et al*., 2018; Yazdanshenas *et al*., 2016). Traditional medicines have also been the fundamental source of modern medicine, drug discovery, and synthesis (Qasim *et al*., 2014; Stanley *et al*., 2014). Traditional medicines are considered to be highly effective in the treatment of assorted illnesses (Rokaya *et al*., 2014). Up to date, more than 70% of people in the third world countries use traditional medicines as an alternative to primary health care (Chen *et al*., 2016; Kayani *et al*., 2014; Mahomoodally, 2013; Maroyi, 2011; Mazid *et al*., 2012; Scott *et al*., 2004; Sigidi *et al*., 2016). According to Mander *et al*. (2007), about 27 million native South Africans still rely upon traditional medicines for treating a range of health problems. Among the utilized species, there are taxa that are threatened with extinction due to overharvesting and habitat destruction (Harisha and Padmavathy, 2013; Kala and Sajwan, 2007). The habit of using threatened medicinal plant species by both village and city communities countrywide and across the globe continues despite the available legal implications set to restrict their collection (Kala, 2005; Ndhlala *et al*., 2011; Zschocke *et al*., 2000). Regardless of the availability and accessibility of modern medicines countrywide and worldwide (Seshathri, 2012), a large number of dwellers in the Soutpansberg Region continues to rely on and habitually

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preferred the use of herbal medicines without considering their conservation status. The high demand of plant resources due to their medicinal properties has been a major cause of threatened species decline (Van Andel *et al*., 2015; Williams *et al*., 2013; Yao *et al*., 2012), including the species belonging to genus *Asparagus* L. (Asparagaceae).

It is evident that many species within the genus, *Asparagus* are being used for medicinal or ornamentals (Goyal *et al*., 2003; Norup *et al*., 2015), and they are also listed as either Endangered, Vulnerable, or Near Threatened (Raimondo *et al*., 2009). The genus *Asparagus* L. is considered to have more than 200 species distributed within the arid and semi-arid zones worldwide (Fukuda *et al*., 2005; Kubota *et al*., 2012). About 120 species, including *Asparagus sekukuniensis* have been recorded in Southern Africa, Europe, and Asia (Batchelor and Scott, 2006; Fellingham and Meyer, 1995). *Asparagus sekukuniensis* is endemic to the Limpopo province, South Africa and categorized as Endangered as its habitat is widely transformed and degraded due to mining, new settlement development, over-grazing, crop cultivation, and over-collection as an herbal medicine (Burrows *et al*., 2012; Mukhopadhyay and Ray, 2013). However, there is a scant of literature on the diseases cured by the species, parts used, dosage, and how this species is administered in the traditional health care systems. Therefore, this study aimed at documenting ethnomedicinal uses of *A. sekukuniensis*, in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa. As like in other aboriginal cultural communities worldwide (Bhat *et al*., 2013), a large amount of knowledge about the medicinal use of *A. sekukuniensis* in Soutpansberg's traditional health care systems is transmitted orally and this wealth of knowledge need to be documented to avoid its subsequent loss. This could not only preserve the Vhavenḓa's traditional health care systems and knowledge but also provide baseline data needed for advanced research on the species.

MATERIALS AND METHODS

Study site description

The current investigation was conducted in four sub-villages of a Vhulaudzi village in Soutpansberg East, Vhembe Biosphere Reserve, Limpopo province, South Africa (Fig. 1 and Table 1). Study sites were located within the north-eastern region of the Makhado Local Municipality, along the Witflag road to Tshikombani which diverge from N1 north route at approximately 3.5 km from Louis Trichard Makhodo (Fig. 1 and Table 1). The study sites covered the combined surface area of roughly 6.99 km^2, with the combined estimated population size of 8 276 people (Census, 2011). The study sites are predominantly occupied by the black ethnic group of Vhavenḓa tribe, who also speak Tshivenḓa as their native language. Vegetation type of study sites is considered to be savanna bushveld (Luseba and Tshisikhawe, 2013). Climatically, the study sites are described by a warm-wet summer (span from October to April) and cold-dry winter (May to September) (Edokpayi *et al*., 2016; Gumbo *et al*., 2016; Kephe *et al*., 2016), with an average annual rainfall range from 300 mm (winter season) to 820 mm (Summer season) (Mpandeli, 2014), and the average annual temperature range from 20ºC during the winter season and 30ºC in summer (Mzezewa and Rensburg, 2011). The topography and geological features of the study sites include Bushveld Igneas complexity, Karoo systems, Limpopo Belt Archaean Cratons, Kalahari Cratons, and the Wylies Poort geological formation of the Soutpansberg Group (Barton *et al*., 2006; Mostert *et al*., 2008).

Ethnobotanical data collection and analysis

Ethnobotanical data about the medicinal uses and administration of *A. sekukuniensis* in the treatment of various ailments were gathered from May to December 2018, with an aid of semi-structured dialogues with participants. A total number of 125 participants were arbitrarily chosen, and prior signed informed consent permitted by the University of Fort Hare Research Ethic Committee (Reference no. MAR031SRAM01) was obtained from all of them. Among the participants, 44 were laypeople (35.2%), 18 were subsistence farmers (14.4%), and the combined total of 63 specialists were herbal-healers (50.4%) (Fig. 2). Among specialist herbal healers, there was 37 child health-care healer (29.6%), 14 wound healers (11.2%), and 12 general healers (9.6%) (Fig. 2). To intensify the participation confident and smooth flow of ideas amongst the interviewees, face-to-face dialogues were carried-out together with all the participants, at the individual level, using their own local language (Tshivenḓa). To maintain the high-level standard of legitimacy, accuracy and validity of the given answers during the interview sessions, equivalent questions were administered to all the participants of this study. Gathered data were kept in a Microsoft Office spreadsheet program and later analyzed using

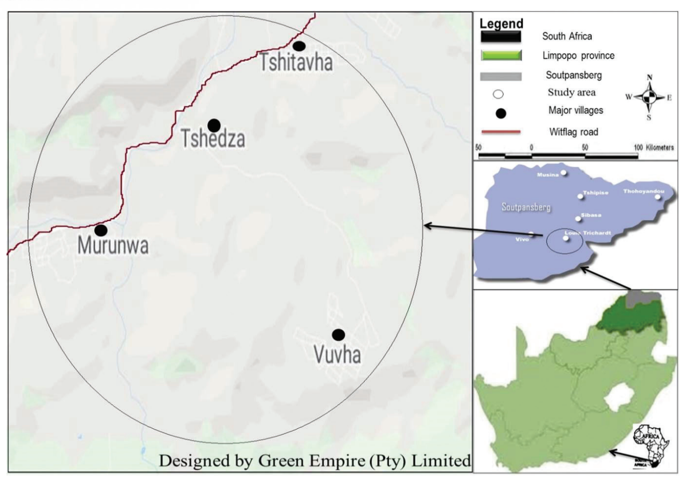

Figure 1. Locality map of the study areas

Table 1. Coordinates of the location of the study areas.

Vhulaudzi sub-villages	Latitudes	Longitudes
Muruṅwa village	−22°58′23.31″S; −22°58′55.94″S	30°9′19.89″E; 30°10′1.37″E
Tshedza village	−22°58′6.77″S; −22°58′28.53″S	30°10′31.56″E; 30°11′41.36″E
Tshiṭavha village	−22°57′51.76″S; −22°57′41.67″S	30°10′47.55″E; 30°12′26.35″E
Vuvha village	−22°59′13.26″S; −22°59′39.93″S	30°11′44.13″E; 30°12′34.04″E

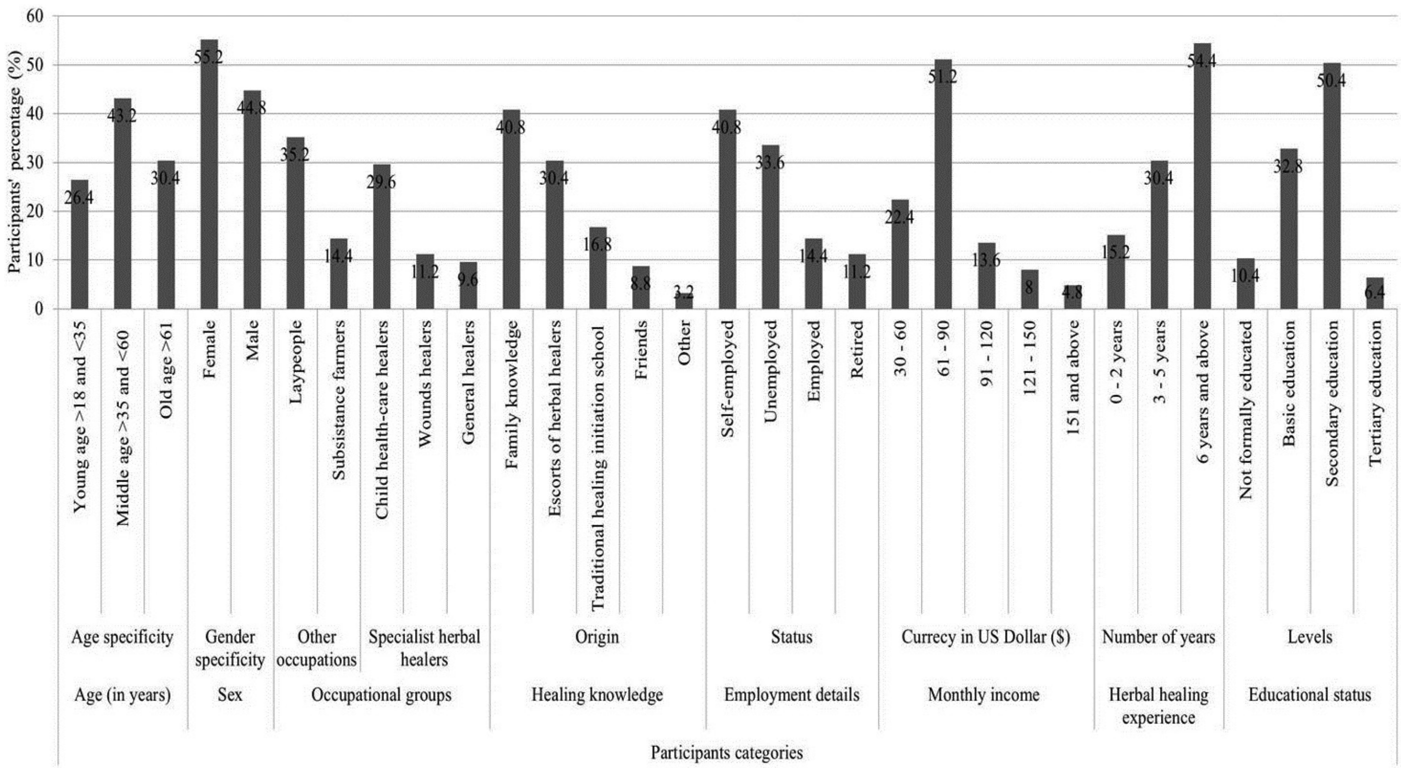

Figure 2. participant's biographical information.

Table 2. Ethnobotanical uses, preparations, and administration [Key: A—Mabogo (1990), F—frequency, and FL (%)—fidelity level percentage] (Note: *Asparagus Sekukuniensis* is locally known as Lufhaladza makole-lwa-thavha/ Muri-wa-muthuso)

Ailments	Used parts	Preparation modes	Administration modes	F (n = 125)	FL (%)	No. of same use citations
Enhancement of fontanelle closure in infants	Root	Burned black ashes are ground into fine powder and then mixed with saturated oil	Small cuts are made on the skin around the fontanelle part using a razor-blade and then medication is administered to the bleeding area	31	24.8	None
Convulsions in infants	Whole plant	The grounded powder is mixed with a fine powder made from barks of *Maerua angolensis* DC. subsp. *angolensis.*	Small cuts are made around or on different body parts of the newly born baby using a razor blade to allow blood to come out and then the medication is administered into the bleeding area to allow it to enter into the blood stream. Afterwards, the same mixture of powder is then poured into a heated clay pot without water while covering the patient with a blanket to contain the produced smoke	28	22.4	1 (A)
Vaccination of epilepsy in infants	Whole plant	Burnt to produce smoke and ashes.	The naked newly born baby carried by the herbal practitioner is moved around the produced smoke three times per day (morning, afternoon and evening) for the period of a week. The burned ashes are then mixed with the urine of the rock rabbit ("Ṱhulo") and then taken orally twice per day until the newly born baby is two years old. The mixture of ashes and urine of rock rabbit is called "Muuluso"	22	17.6	None
Unhealed or cancer-related wounds	Root	A decoction of fresh root, dried root is ground into a fine powder and mixed with a powder made from the barks of *Ozoroa reticulata* (Baker f.) R.Fern. & A. Fern	A decoction of fresh roots taken orally whereas, a mixture of powders is administered into the unhealed wounded body part	19	15.2	None
Genital wounds	Root.	The dried root is ground into a fine powder and then mixed with saturated oil	Administered to the wounding area	15	12.0	None
Boil in both humans and live stocks	Whole plant	Fresh materials are boiled to produce steam	Steam is applied around the area where boil occurs to soften it so that it gets healed	10	8.0	None

components of the descriptive statistic, such as frequency of occurrence and fidelity level (FL) (%). FLs (%) were determined using the following formula: FL (%) = $N_p/N \times 100$, where FL (%) is the FL percentage; N_p, the number of individuals who cited a certain use, and N is a total number of individuals who cited all the uses (Al-Qura'n, 2009; Umair *et al*., 2017). Since all participants have cited ethnomedicinal uses of *A. Sekukuniensis*, *N* was equal to 125.

Plant identification and specimen collection

Gathered data were supplemented by field inspection walks together with participants for plant identification purposes and specimen collection. The voucher specimen collection permit (ZA/LP/92932) was granted by the Limpopo Department of Economic Development, Environment and Tourism. During the field inspection walk, participants have identified the plant species of interest using its vernacular name and sample specimen was then collected, prepared (pressed and dried), and numbered (RAMLJ 013). A voucher specimen was then deposited at the Botany Herbarium, Life Science and Chemistry Building, the University of Venda for further identification by taxonomists.

RESULTS AND DISCUSSION

Ethnomedicinal uses

Table 2 reports on the recorded ethnomedicinal uses, preparation techniques, and administration procedures of *A. sekukuniensis* by the Vhavenḓa people in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa. A total of six ethnomedicinal uses of *A. sekukuniensis* were recorded in this study. FL of the six recorded uses ranged from 8.0% to 24.8% (Table 2). More than 64.8% of all the participants in the current study seemed to be communally utilizing *A. sekukuniensis* for child health care-related ailments (Table 2). According to the participants, ensuring child's health was always an important cultural norm for Vhavenḓa people in the region and therefore, all newly born infants undergo traditional vaccination rituals to strengthen their immune systems called *muthuso* (personal communication with the participants). According to Rikhotso (2016), *muthuso* referred to the use of varied herbal medicines to protect the infants against miscellaneous ailments. The communal use of certain medicinal plant species by various herbal healers proves the effectiveness and therapeutic reliability of these implicated species (Semenya and Maroyi, 2018). Participants across the study sites have stated that they utilized *A. sekukuniensis* for curing the variety of ailments, including enhancement of fontanelle closure in infants (FL = 24.8%), convulsions in infants (FL = 22.4%), vaccinating epilepsy in infants (FL=17.6%), treating the unhealed or cancer-related wounds (FL = 15.2%), genital wounds (FL = 12.0%), as well as boils treatment in both human beings and livestock (FL = 8.0%) (Table 1). Thus, this study argued that the repetitive use of *A. sekukuniensis* in addressing miscellaneous ailments (Table 2) demonstrates the variety of biological activities it may possess. The aforementioned statement was supported by other scholars worldwide (Cheikhyoussef *et al*., 2011; Khan *et al*., 2014; Mojahedi *et al*., 2014). However, Jamila and Mostafa (2014) argued that the reliability of traditional herbal medicines, in the treatment and prevention of certain ailment, should not be doubted, but phytochemical validated for authenticity.

The utilized parts of *A. sekukuniensis* included roots (50%) and whole plant (50%) (Table 2). The equal utilization proportions of *A. sekukuniensis* parts were influenced by the fact that healers do not want to lose any materials of this species since this plant is scanty to be found (personal communication). This was endorsed by the study done by Burrows et al. (2016), whereby *A. sekukuniensis* was categorized as an Endangered species under the International Union for Conservation of Nature. Furthermore, this study argued that the equal utilization of *A. sekukuniensis* parts demonstrates the equal therapeutic efficacy (Ramarumo *et al*., 2019). Moreover, the results of this study do not conform to other ethnomedicinal studies in the region since leave was portrayed as the most frequently used plant part (Luseba and Tshisikhawe, 2013; Mahwasane *et al*., 2013; Masevhe *et al*., 2015; Mulaudzi *et al*., 2012).

CONCLUSION

The current study has enlightened five uses associated with *A. sekukuniensis* which were never reported elsewhere in the world (Table 2). *Asparagus sekukuniensis* appeared to be an important herbal medicine against infant ailments, wounds, infections, and infestations. These findings, therefore, call for the evaluation of the phytochemical and pharmacological properties of this species.

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CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest.

ETHICAL APPROVAL

The ethical authorization of this study was permitted by the University of Fort Hare's Research Ethic Committee (Reference no. MAR031SRAM01).

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Bowiea volubilis Harv. *ex* Hook.f. subsp. *volubilis*: A therapeutic plant species used by the traditional healers in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa

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Abstract

Traditional healers in South Africa have been using *Bowiea volubilis* as herbal medicine against assorted diseases since time memorial. This study was aimed at documenting therapeutic uses of *B. volubilis* by the traditional healers in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa. Data about medicinal uses of *B. volubilis* were gathered via interviews with 133 traditional healers, using semi-structured questionnaires. Five therapeutic uses associated with *B. volubilis* were recorded, including being utilized as herbal medicine for rash and skin smoothening (FL=24.8%), anthelmintics in infants (FL=23.3%), liver infections (FL=18.8%), pelvic pains in women (FL=17.3%) and jaundice in infants (FL=15.8%). Among the recorded therapeutic uses, three of them were reported for the first time in this study. The results of this study, calls for further investigations focusing on phytochemical and pharmacological properties of the plant species. There is a need to domesticate B. volubilis in home gardens as a conservation strategy since the species is sought after as herbal medicine and threatened with extinction.

Keywords: *Bowiea volubilis*, Soutpansberg Region, therapeutic uses, threatened plant species, Traditional healers, Vhembe Biosphere Reserve

INTRODUCTION

Bowiea volubilis Harv. *ex* Hook.f. subsp. *volubilis* is a deciduous climber and bulb plant species belonging to family Hyacinthaceae [1]. This plant species is considered to be an unusual succulent species with climbing inflorescences adapted to trap light and photosynthesize without aerial leaves [2]. It has a bright-green fleshy stem and its bulb can reach a diameter of 150 mm in growth and the diameter of its flowers range from 16 to 24 mm, while the fruits can reach 25 mm [3]. In the southern African region, *B. volubilis* is distributed in South Africa, Mozambique, Zimbabwe, Zambia, Angola, Uganda and Tanzania [2–4]. In South Africa, the distributional range of the plant species stretches from Eastern Cape, Kwazulu-Natal, Mpumalanga, Gauteng to Limpopo Provinces [4].

Traditionally, plant species are considered integral for human wellbeing [5]. Indigenous knowledge about therapeutic uses of plant species against assorted ailments have existed since time immemorial [6–7]. Regardless of the available modern therapeutic means worldwide, more than 80% of global population, particularly in rural areas heavily rely upon herbal medicines for their well-being [8–9]. It is evident that more than 4 000 plant species in southern Africa are being utilized as herbal medicines for assorted diseases [10] which includes the utilization of both threatened and non threatened plant species [11]. Raimondo *et al.* [4], has assessed the conservation status of *B. volubilis* using IUCN Red List Categories and Criteria version 3.1 and categorized the species as Vulnerable (VUA2ad) [12].

It is evident that many bulb plant species, including *B. volubilis* are on the verge of extinction risk due to numerous threats, including over-harvesting as herbal medicine, habitat destruction, human settlement and agricultural expansion [13–14]. Many species under the family Hyacinthaceae including *B. volubilis* are being utilized as herbal medicines and ornamentals [1], and they are also listed as threatened plants [4,11]. In various parts of South Africa, *B. volubilis* is known by its numerous vernacular names [15–16], including being called Nyalakhobvu or Khobvumutovu in Tshivenḓa language in the Soutpansberg, Vhembe Biosphere Reserve, Limpopo Province. Sati [17], articulated that medicinally used plant species including *B. volubilis* plays an integral role in the growth of subsistence economy for local people, whereas, Louw *et al.* [18] portrayed the history of using herbal medicines in traditional health care systems as the continuing heritage [19]. Therefore, South African traditional healers have been using *B. volubilis* as herbal medicine against miscellaneous diseases since time immemorial [15,20,21].

Jäger and van Staden [22], portray the use of herbal medicine in South African traditional health systems as an equal and important segment of national primary health care, whereas, Hannweg *et al.* [23] illustrated *B. volubilis* as an essential herbal medicine within South African traditional health care system. The literature studies showed *B. volubilis* as one of the top five frequently utilized therapeutic plant species countrywide [24–25]. However, there is no record of published data about the therapeutic uses of the plant species in the Soutpansberg area of the Vhembe Biosphere Reserve and the entire Limpopo Province at large [26]. The current study aimed at documenting the therapeutic uses of *B. volubilis* by the traditional healers in the Soutpansberg area of the Vhembe Biosphere Reserve, Limpopo Province, South Africa. The results of this study could potentially be envisaged as a baseline towards drug synthesis.

MATERIALS AND METHOD

Description of the study place

The current study was conducted in 34 villages in Makhado and Thulamela Local Municipalities in the Soutpansberg area of the Vhembe Biosphere Reserve, Limpopo Province, South Africa (Fig. 1). The study place was located within the coordinates ranging from 22°42´11.005" to 23°0´3.650" south latitudes and 30°11´23.333" to 30°11´58.747" east longitudes. Both sites were predominantly occupied by the Vhavenḓa ethnic group who speaks Tshivenḓa as their native language. The study sites are classified as savanna biome and its vegetation cover is classified as bushveld [27] and Soutpansberg Mountain Bushveld with some small patches of afromantane forest [28]. Climatically the region is characterized by mild-dry winter (stretching from May to September) and warm-wet summer (stretches from October to April), with the annual mean rainfall ranging from 300 mm (winter) to 820 mm (summer) [29–30].

Data gathering and analysis

Data about the therapeutic uses of *B. volubilis* by the traditional healers was garnered in May 2018 until April 2019. An ethical clearance certificate (Reference no. MAR031SRAM01) was granted by the University of Fort Hare, prior to the commencement of data collection. The objective of this study was explained to all the traditional healers of various age groups using their own local language (Tshivenḓa) and subsequently all those who were willing to participate signed an informed consent form (Fig. 2). A total of 133 traditional healers specializing in various categories of herbal healing, including child health care healers, wound and general healers (Fig. 2), were arbitrarily selected with the aid of the local traditional leaders who knows them better. To increase the certainty, participation tenacity and allowance of smooth flow of ideas during the interviews, all traditional healers were visited in their homestead and interviewed individually with the aid of semi-structured questionnaires. To validate the accuracy the given information, the same questions were administered to all the traditional healers. Accumulated data were stored in a Microsoft Office 2010, spreadsheet program and then descriptive statistical analysis was performed using components such as the frequency of occurrence and fidelity level percentage (FL %). The FLs (%) was determined using formula (FL% = $N_P/N \times 100$), cited by Umair *et al*. [31] and Al-Qur'an [32], whereby N_P, embodied a number of traditional healers who cited certain therapeutic use, whereas N, donates total number of traditional healers who cited all the therapeutic usage of *B. volubilis* within the study sites. Therefore, since all traditional healers have cited the therapeutic uses of *B. volubilis*, then N, was equivalent to 133.

Plant specimen collection and identification

A specimen collection permit (Reference no. ZA/LP/92932) was licensed by the Limpopo Provincial Department of Economic Development, Environment and Tourism. Accumulated data were supplemented by field visit-inspection together with all the traditional healers, for the purpose of plant identification and specimen collection purpose. Firstly, traditional healers identified the target plant species using its vernacular name and then the specimen was collected, prepared (pressed or dried), assigned the voucher number (RAMLJ 015) and deposited in Botany Herbarium of the University of Venda for further examination by taxonomists.

RESULTS AND DISCUSSION

The results showed that *B. volubilis* is being utilized by local traditional healers as herbal medicine against assorted diseases (Table 1). More than 80% of traditional healers within the study sites seemed to mix *B. volubilis* with other herbal remedies while using decoction as a major preparation method (Table 1). This was to intensify its therapeutic efficacy against miscellaneous diseases (personal communication), whereas decoction is considered to be the simplest method in traditional therapeutic preparation [33]. Ugulu [34], argued that mixed medicinal plant species could provide the most effective therapeutic treatment against target disease. This was also endorsed by other scholars worldwide [35–37]. The total of five therapeutic uses associated with *B. volubilis* were recorded in the current study and their fidelity level (FL) ranged from 15.8 to 24.8%. The recorded therapeutic uses of the plant species includes being utilized as herbal medicine for rash and skin smoothening (FL=24.8%), anthelmintics in infants (FL=23.3%), liver infections (FL=18.8%), pelvic pains in women (FL=17.3%) and jaundice in infants (FL=15.8%) (Table 1). The recurring therapeutic use of *B. volubilis* by traditional healers against assorted diseases delineates high potential of bioactive compounds it may possess, wealth of pharmacological knowledge among healers and dynamism within the traditional therapeutic means. This was supported by other scholars in the field [38–40]. According to louw *et al.* [18], plant species under family Hyacinthaceae including *B. volubilis* contains large amount of bioactive compounds to be used against assorted diseases. The current study lack phytochemical validations. Tengö *et al.* [41], argued that indigenous therapeutic knowledge requires no validations since it has already been validated through its developmental stages long time ago, whereas, Jamila and Mostafa [42], stated that herbal therapeutic efficacy should not be doubted, but pharmacological evaluated for precisions. Furthermore, therapeutic use of *B. volubilis* against multiple diseases also demonstrates its high level demand within study sites. Therefore, this study argued that the continuous unsustainable harvest of *B. volubilis* for any purpose within the region could potentially derive its population towards the verge of extinction risk.

Table 1: Therapeutic uses of *B. volubilis* by the traditional healers in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo province, South Africa (Notes: n – Total number of participants).

Therapeutic uses	**Preparation and recipe**	**Dosage and Administration**	**Parts**	**Fidelity level (%) (n=133)**	**Cited before**
Rash and skin smoothening	Chopped fresh bulb is crushed and squeezed to produce the liquid extracts	Five to ten drops of liquid extract are applied on skin sore as body lotion twice per day for five days	Bulb	24.8	Yes [16,20,24]
Infant anthelmintic	Decoction of boiled and chopped pieces of fresh bulb and fresh root of *Athrixia phylicoides* DC.	Two spoons of decoction are taken orally, three times per day for one month	Bulb	23.3	No
Liver infections	Decoction of boiled fresh parts (whole plant) together with fresh roots of *Momordica boivinii* Baill, *Momordica balsamina* L., *Momordica cardiospermoides* Klotzsch, *Momordica foetida* Schumach, *Momordica repens* Bremek.	Decoction on the cup is taken orally, three times per day for two months	Whole plant	18.8	No
Pelvic pains in women	Decoction of boiled and chopped fresh bulb and *Artabotrys monteiroae* Oliv., is mixed with maize meal to make soft porridge	Taken as soft porridge twice per day, for one week	Bulb	17.3	Yes [11,20]
Infant jaundice	Decoction of boiled fresh parts (whole plant) and fresh rhizome of *Rhus lancea* (L.f.) F.A. Barkely as well as *Kniphofia crassifolia* Barker	Decoction on the spoon is taken orally, three-times per days for two weeks	Whole plant	15.8	No

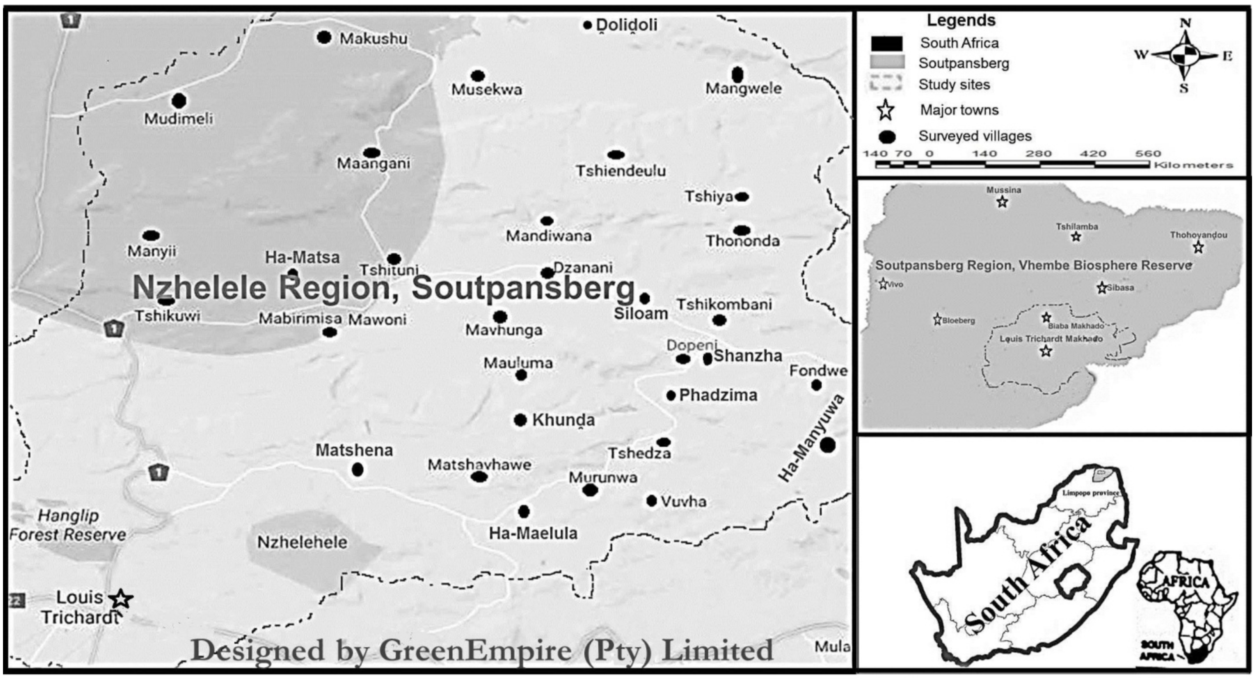

Figure 1: Locality map of the study sites

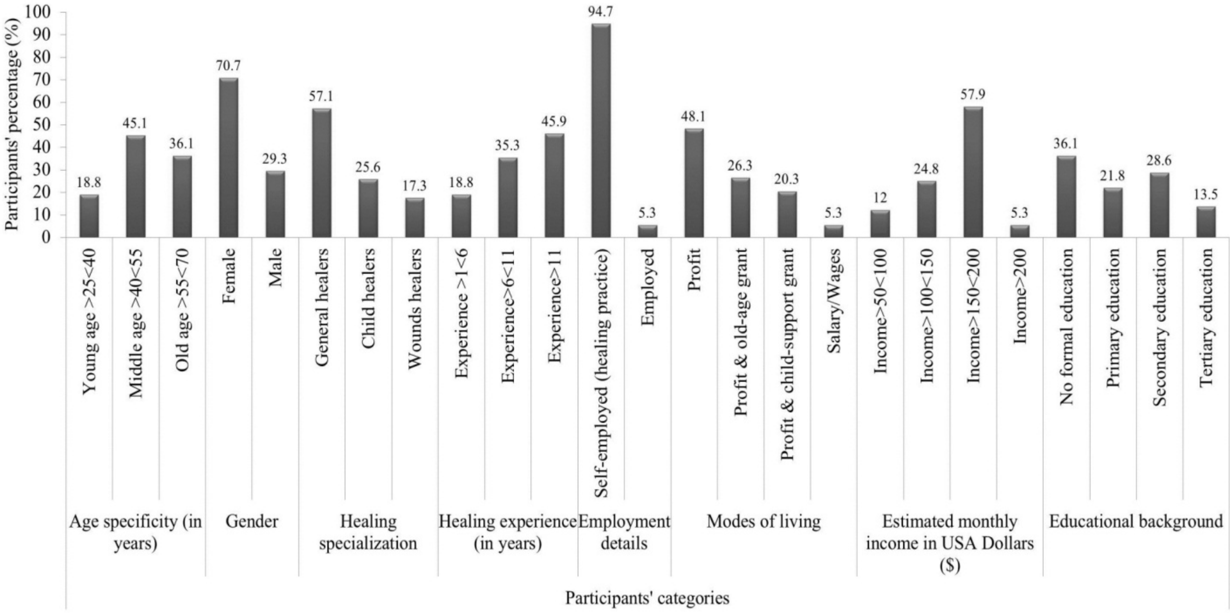

Figure 2: Participants' biographical details

CONCLUSION

The present study has unveiled novel evidence about the therapeutic uses associated with the utilization of *Bowiea volubilis* in the Soutpansberg Region and the entire Limpopo province in particular. From the best of our knowledge, this was the first study to record the therapeutic uses of *B. volubilis* in the Soutpansberg Region and entire Limpopo Province. This study has recorded five therapeutic uses associated with *B. volubilis* within the study sites. Among the recorded therapeutic uses, three of them have never been published before elsewhere. *Bowiea volubilis* seemed to be an important herbal medicine for infant diseases, women's diseases, organ infections and tissue treatment. This study recommended phytochemical and pharmacological property investigations of the plant species. There is an earnest need to detail appropriate conservation strategies for local traditional healers to naturally growing scant therapeutic plant species including *B. volubilis* within the dwelling areas.

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RESEARCH ARTICLE

Warburgia salutaris (G. Bertol.) Chiov.: An Endangered Therapeutic plant used by the Vhavenḓa ethnic group in the Soutpansberg, Vhembe Biosphere Reserve, Limpopo province, South Africa

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ABSTRACT:
Although *Warburgia salutaris* is popular and well-known medicinal plant in southern Africa, there is still a wealth of undocumented therapeutic uses of the species within the Vhavenḓa ethnic group in South Africa. The literature studies confirmed that there is a sparse rather than a paucity of information about *W. salutaris* preparation method, administration processes and dosage used for therapeutics. This study was aimed at documenting the therapeutic uses of *W. salutaris*, by the Vhavenḓa ethnic group within the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa. Data on therapeutic uses of the species were collected using semi-structured interview, supplemented by field guided-walk with 346 participants. The total of nine therapeutic uses of *W. salutaris* were recorded and this includes being used as herbal medicine for bilharzia (FL=15.3%), womb cleaning after recurring miscarriages (FL=13.8%), period pain (FL=12.5%), ear-ache (FL=8.8%), asthma (FL=7.5%), spinal cord pains (FL=10.0%), genital sore (FL=8.1%), colds (FL=6.5%) and toothache (FL=17.7%). The therapeutic preparation process of the species includes decoction (33.4%), soaking (22.2%), powder-grounding (22.2%) and leaf-squeezing (22.2%) whereas, the administration processes involved oral (45%), smoking (11%), bathing (11%), injection (11%), sap-pouring (11%). This study present novel traditional therapeutic knowledge associated with *W. salutaris* which was never been reported before. The therapeutic uses of *W. salutaris* in the traditional health care seemed to be prevalent and reliable in combating illnesses in scant resources communities.

KEYWORDS: Soutpansberg Region, Therapeutic uses, Vhavenḓa ethnic group, Vhembe Biosphere Reserve, *Warburgia salutaris.*

INTRODUCTION:
Genus *Warburgia* fall under the family Canellaceae which umbrella a total of five taxa, including *Warburgia salutaris* (G. Bertol.) Chiov[1,2,3]. The utilization of plant species still remains an integral part of living in many aboriginal indigenous communities[4], with no exception to Africa. The unsustainable utilization of *W. salutaris* within the African traditional health care systems across the Southern and Central African Regions have deriven the species towards the verge of extinction danger[2,5,6,7].

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Due to over-harvesting and habitat transformation, *W. salutaris* was listed as endangered species by International Union for Conservation of Nature (IUCN)[8,9]. In South Africa this species is distributed in KwaZulu-Natal, Mpumalanga and Limpopo provinces[10]. As like in many indigenous communities[11] across the South Africa, the use of herbal medicines for therapeutic against assorted ailments is still tremendously pivotal, with no exception to the Soutpansberg Region of the Vhembe Biosphere Reserve, Limpopo Province. Since last decade ago, the use of herbal medicines has gained a tremendous acceptability worldwide[12]. In the Soutpansberg, the knowledge of using plant species as herbal medicines has existed since time immemorial[13] and therefore, this crucial knowledge is being transferred from one generation to another orally, using the words of mouth[14]. The Vhavenḓa ethnic group has been using *W.*

salutaris for therapeutics against miscellaneous illnesses for many decades[15,16]. Although ethnomedicinal uses of *W. salutaris* seemed to be popularly known and well-documented[2,7], there is still a wealth of undocumented therapeutic uses of this plant species existing within the Vhavenḓa ethnic group. The literature studies confirmed that there is a sparse rather than a paucity of information about *W. salutaris* preparation method, administration processes and dosage used for therapeutics[17,18]. This study aimed at documenting therapeutic uses of *W. salutaris*, its preparation methods, administration and dosage used by the Vhavenḓa ethnic group within the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa. This study could not only preserve indigenous therapeutic knowledge of the Vhavenḓa ethnic group, it could also provide baseline information required to advance ethnopharmacology and its therapeutic efficacy countrywide and worldwide.

MATERIALS AND METHOD:

Study area description:

This study was conducted in 17 villages within the Nzhelele Region, in the Soutpansberg-east, Vhembe Biosphere Reserve, Limpopo Province, South Africa (Fig. 1). The study areas are located in the north-eastern part of the Makhado Local Municipality within the coordinates ranging from -22°52'1.079" to -22°56'10.064" South latitudes and 30°2'4.949" to 30°16'52.988" East longitudes. These villages covered the combined surface area of about 14000 km^2 and its population size is approximately 18000 people[19]. The area is predominately occupied by the Vhavenḓa ethnic group.

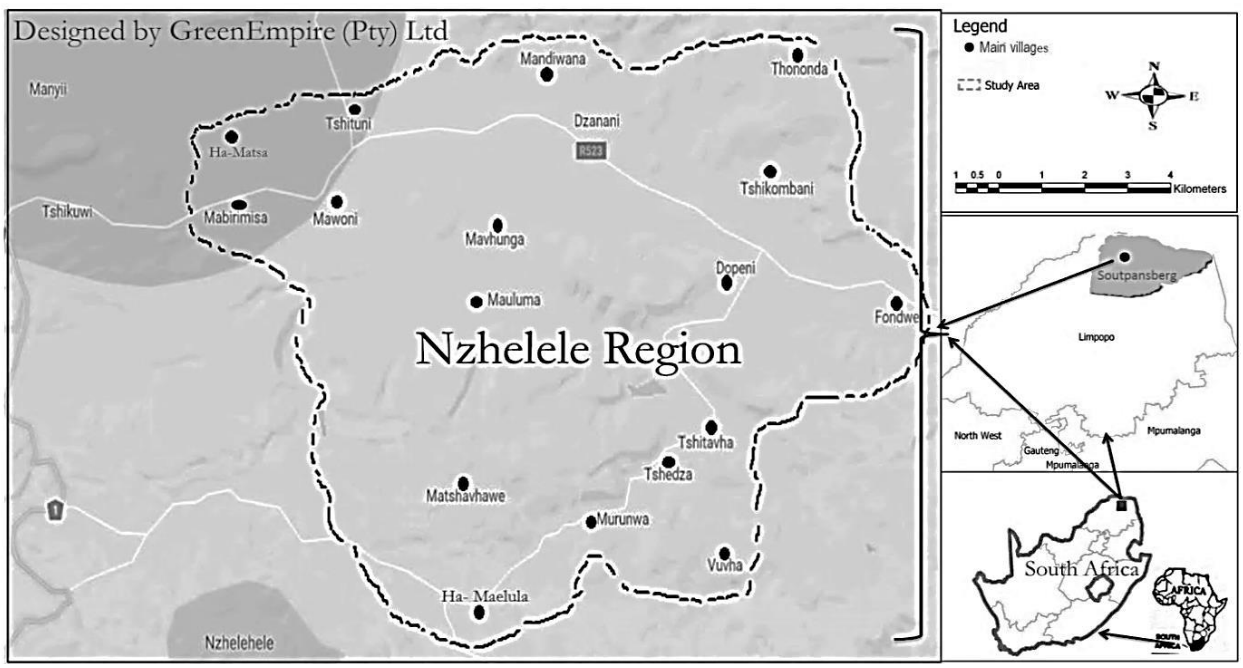

Figure 1: Locality map of the study areas

The vegetation form of this region is classified as the Bushveld of the savanna biome[20] and it receives an average annual rainfall ranging from 300 to 800 mm, with the highest rain received during the summer (stretch from October to April) and less during winter season stretching from May to September[21,22]. The average annual temperatures range from 20 ºC during winter to 30ºC in summer season[23].

Data collection and analysis:

Information about the therapeutic uses of *W. salutaris* and its preparation forms, administration and dosage uses were collected during May 2018 and February 2019, through semi-structured interview with participants. The total of 346 participants of varied age-groups took-part in this study (Fig. 2), after signing prior-informed consent endorsed by the University of Fort Hare’s Research Ethic Commit (Reference no. MAR031SRAM01). Among them there were laypeople (39.3%), traditional healers (22.0%), herbalists (11.0%), subsistence farmers (12.4%), hunters (7.5%) and other categories (7.8%) (Fig. 2). Interview with the participants were carried-out at the individual level. Similar dialogues were carried-out with all the participants for veracity, high standard legitimacy and smooth flow of ideas among them.

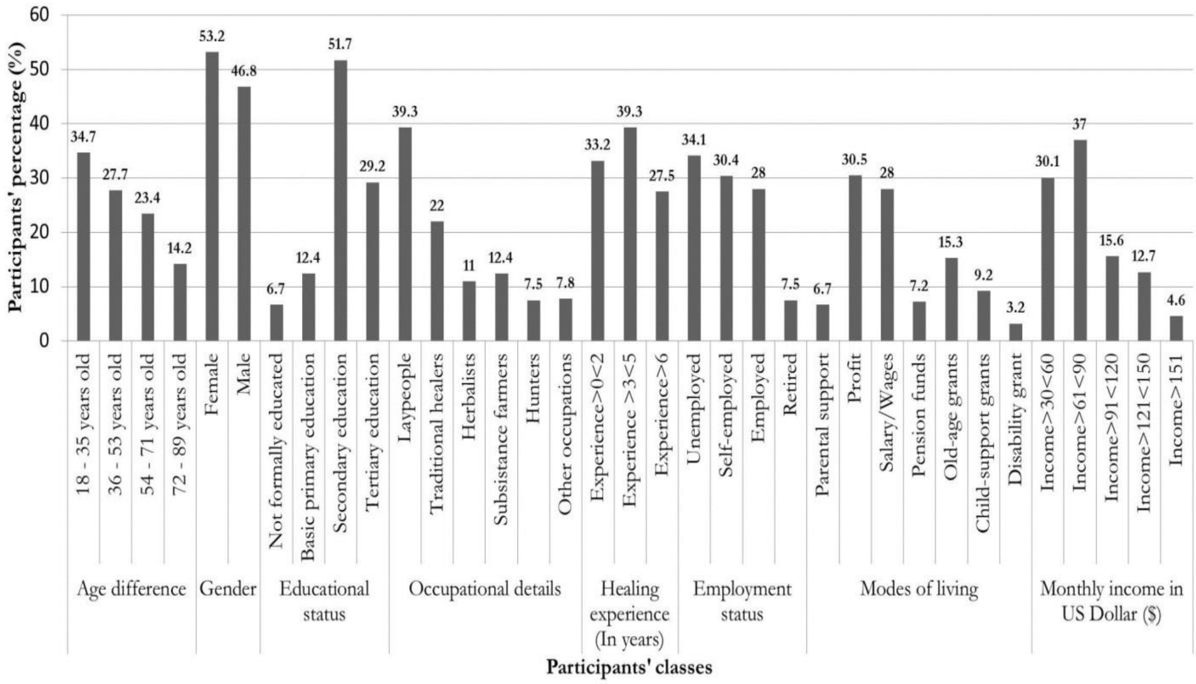

Figure 2: Participants' biographical information

Data gathering processes were then supplemented by field visit walk accompanied by participants for species identification and specimen collections, permitted by the Limpopo Department of Economic Development, Environmental and Tourism (permit number: ZA/LP/92932). Collected specimen was prepared accordingly, given the voucher number (RAMLJ014) and then stored at the University of Venda's Botany Herbarium for further identification by taxonomists. Collected data were entered into a Microsoft Office, spreadsheet program and then descriptive statistical analysis, such as frequency of occurrence and fidelity level (%) were performed respectively. Fidelity levels (%) were calculated using the formula described by Al-Qura'n[24] [FL (%) = $N_P/N \times 100$], where FL (%), is the fidelity level percentage, N_P, the number of individuals who cited the use of the species and N, represent the total number of participants who cited all the uses. It is, therefore, important to note that all the participants within the study areas have cited the uses of *W. salutaris* and N, was equivalent to 346.

RESULTS AND DISCUSSION:

Table 1, delineates the therapeutic uses of *W. salutaris* in Nzhelele Region. The fidelity level (FL), of *W. salutaris* uses ranged from 6.3 to 17.7% (Table 1). *Warburgia salutaris* was being used in the treatment of more than one illness (Table 1). This demonstrated that the species is highly demanded within the area. The results showed than two-third (69.4%) of *W. salutaris* therapeutic preparations involved combination with other plants (Table 1). This was done to increase its therapeutic efficacy (personal communication). The fundamental way to rapidly heal illnesses is by increasing therapeutic effectivity[25,26]. According to Ngarivhume et al.[27], the mixture of herbal medicines is considered prevalent among African traditional therapeutic means. The mixing of *W. salutaris* with other herbal medicines only occurred when treating the following illnesses, toothache (FL=17.7%), bilharzia (FL=15.3%), womb cleaning after recurring miscarriages (FL=13.8%), ear-ache (FL=8.8%), asthma (FL=7.5%) and colds (FL=6.5%) whereas, non-fusion occurred when treating, period-pains (FL=12.5%), spinal cord-pains (FL=10.0%) and genital sores (FL=8.1%) (Table 1). The fusion of *W. salutaris* with other plants emphasizes the wealth of ethnopharmacological knowledge within the Soutpansberg Region. This conforms to study done by Olivier and van Wyk[28]. According to De Wet et al.[29] and Ramarumo et al.[13], the mixing of medicinal plant species resembles the existence of dynamism and adaptability among the traditional therapeutic approaches.

Table 1: Therapeutic uses of *Warburgia salutaris* (n=total number of participants).

Illness and citations	Preparation	Administration and dosage	Parts used	Fidelity level % (n=346)
Toothache (in human beings and dogs)[17]	Fusion of fresh barks with root of *Eriosema psoraleoides* (Lam.) G.Don are soaked in warm water for about 24 hours	Infusion on the cup is used as mouth-wash three-times per day (morning, afternoon and evening) (each tumbler per wash) for 7 days	Barks	17.7
Bilharzia	Mixture of bark with leaves of *Aloe marlothii* A. Berger subsp. *marlothii* and barks of *Pterocarpus angolensis* DC., *Peltophorum africanum* Sond., and *Senna petersiana* (Bolle) Lock, are boiled in water for an hour	Decoction on the cup is orally taken, three-times per day for 4 weeks (in the morning, afternoon and evening)	Barks	15.3
Womb cleaning (after a miscarriage and enhancing the chances of getting impregnated again)	Mixture of fresh barks with roots of *Cucumis africanus* L. f., are soaked in warm water 24 hours	Infusion on the cup is taken orally once per day for three weeks	Barks	13.8
Period pains	Either fresh or dried roots are boiled with water for 45 minutes	Decoction on the cup is taken orally once per day, three days towards the menstruation date	Root	12.5
Spinal cord pains[17]	Dried root is grounded into a fine powder	A Razor-blade is used to make small cuts in the patient's skin along the spinal cord to allow some blood to come out and medication is then applied into the bleeding parts to enter the blood stream	Root	10.0
Ear-ache	Infusion of fresh leaves with those of *Hibiscus cannabinus* L., are crushed and squeezed to produce a liquid extracts	One drop of the extracted liquid is poured into painful ear twice per day	Leaves	8.8
Genital sore	Fresh leaves are crushed and squeezed to produce liquid extracts and about 10 drops of the extracts poured into a 1 liter bottle of warm water, containing 1 spoon of dissolved salt	The solution is used to wash the genital sores twice per day (in the morning and evening)	Leaves	8.1
Asthma	Mixture of dried leaves with those of *Helichrysum kraussii* Sch.Bip., are grounded into powder	The powdered mixture is smoked as cigarette to heal asthma	Leaves	7.5
Colds[17,30]	Mixture of dried barks and those of *Zanthoxylum capense* (Thunb.) Harv., are boiled in water for 30 minutes	Decoction is orally taken to cure or vaccinate colds	Barks	6.3

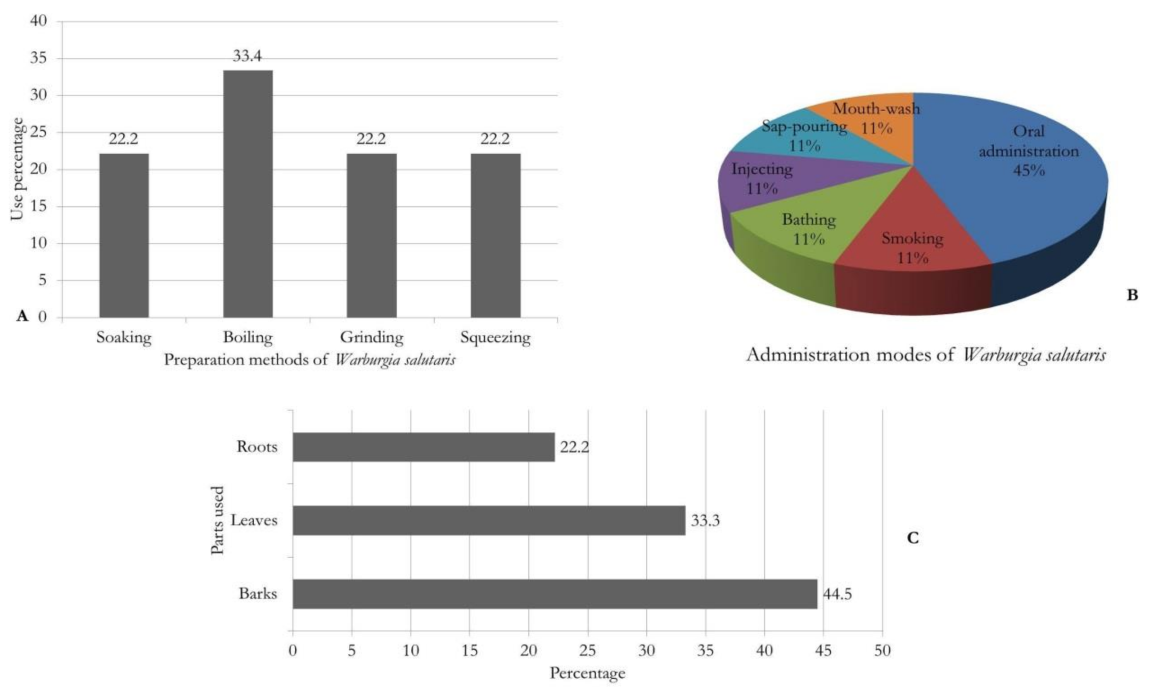

Figure 3: The preparation method and administration processes of *Warburgia salutaris* therapeutics.

The results showed that there are variations among pharmacological preparation and administration of *W. salutaris* (Fig. 3A and Fig. 3B). Mahomoodally[31], indicated that African traditional remedies varied in their preparation and administration modes, depending on the nature of illness to be treated, whereas, Gurib-Fakim[32], articulated that difference illnesses varied in their treatment procedures. Four preparation methods and six administration procedures, were being used across the study areas (Fig. 3 and Table 1). Boiling (33.4%), was the most cited preparation methods of *W. salutaris* therapeutics, followed by soaking (22.2%), grinding (22.2%) and squeezing (22.2%) were equally used (Fig. 3A). Boiling is considered the oldest and reliable method used for traditional therapeutic preparation[33]. Among the recorded administration processes of *W. salutaris* against illnesses, oral (45%) was the most frequent administration mode, whereas, smoking (11%), bathing (11%), injection (11%), sap-pouring (11%) and mouth-wash were equally used (Fig. 3B). Bartel[34], demonstrated an oral administration mode as doable, cost effective and not requiring supervision of practitioner. Nevertheless, participants have reported that the duration period and dosage of *W. salutaris* varies from one patient to another, depending on the nature of the illness (Table 1). The variation in duration period and therapeutic dosage used against illnesses, proved that traditional therapeutic means is not static, but dynamic[35]. Arnold and Gulumian[15], argued that the duration period and dosage of traditional medicine varied from one traditional health practitioner to another. Bark (44.55), was the most frequently used part of *W. salutaris*, followed by leaves (33.3%) and roots (22.2%) (Fig. 3C). These results aligned with ethnomedicinal studies done in the Sesheke District, Western Province, Zambia and Sekhukhune District, Limpopo province, South Africa[36,37].

CONCLUSSION:

This study present crucial traditional therapeutic knowledge associated with *W. salutaris*. Six novel therapeutic uses associated with *W. salutaris* were recorded in this study and have never been reported elsewhere (Table 1). *Warburgia salutaris* preparation method, administration modes and dosage used for therapeutics seemed to be varying from illness to illness. Therefore, this study argued that traditional therapeutic means are still prevalent and reliable for combating illnesses in scant resources communities. Since *W. salutaris* seemed to be highly demanded for its therapeutic potential within the study areas, this study calls for the re-evaluation of its conservation status within the study area.

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Euphorbia pulvinata Marloth: A useful succulent plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa

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The use of *Euphorbia pulvinata* by the Vhavenḓa tribe in Vhulaudzi and its adjacent villages has been part of their tradition, culture and enhancing their livelihood for centuries. The current study aimed at documenting ethnobotanical uses of *E. pulvinata* in Vhulaudzi and adjacent villages, Nzhelele, Vhembe Biosphere Reserve, Limpopo Province, South Africa. Data on ethnobotanical uses of the species was collected through interviews using semi-structured questionnaires. A total of 120 participants took part in the current study, including nine traditional healers, herbalists (21), avifaunal hunters (11), subsistence farmer (31) and laypersons (48). The fidelity level of the six *E. pulvinata* uses ranged from 5.8 to 35.8%. The recorded uses of *E. pulvinata* included the use of latex as glue (5.8%), insect-lime (17.5%) and birds-lime (35.8%), and other uses included ethnoveterinary medicine (25%), ornamental (9.2%), ritual and magical (6.7%). Plant parts used were latex (59%), followed by root (25%), whole plant (9%) as well as thorns and flowers (7%). Traditional uses and values of *E. pulvinata* are important in addressing livelihood and socio-economic challenges in the Vhembe Biosphere Reserve. These findings provide baseline data needed for the management and regional re-assessment of the conservation status of *E. pulvinata*.

Keywords: *Euphorbia pulvinata*, Succulent, Traditional knowledge, Tshiḓitshinzhi, Vhembe biosphere reserve

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Euphorbia pulvinata Marloth is a succulent species belonging to *Euphorbia* L. genus (spurge or Euphorbiaceae family). The *Euphorbia* is one of the largest genera of flowering plants with over 2000 species[1-6]. The *Euphorbia* has a cosmopolitan distribution, forming characteristic and dominant component of the vegetation of many tropical, semi-arid and areas of Africa, the Arabian Peninsular and Peninsular India[7]. *E. pulvinata* has been recorded in Lesotho, South Africa and Swatini[8-10]. In South Africa, the species has been recorded in the Eastern Cape, Kwa Zulu-Natal, Free State, Mpumalanga and Limpopo provinces[8-10]. *E. pulvinata* is considered to be dwarf plant, low-lying, clustered perennial shrub with succulent, columnal and cylindrical shaped stems[10]. The species grows to a height ranging from 20 cm to 50 cm and has been recorded in high altitude ranging 700 m to 1830 m above the sea level[10, 11]. Previous research revealed that *E. pulvinata* is widely used in horticulture as an ornamental and the species is also considered to be poisonous to stock amimals[12,13]. However, literature studies revealed that there dearth of information on how *E. pulvinata* is utilized by local communities. Since time immemorial, local communities have gathered plant resources to meet their livelihood needs, including using plant species as food, herbal medicine and for socio-cultural purposes[14-16]. Therefore, the current study was aimed at documenting ethnobotanical uses of *E. pulvinata* in Vhulaudzi and adjacent villages, Nzhelele, Vhembe Biosphere Reserve, Limpopo Province, South Africa. This baseline data could provide useful information required to assess the conservation status of *E. pulvinata* in the region.

Methodology

This study was carried out in Vhulaudzi and its adjacent villages, in the Nzhelele Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa (Fig. 1). The study sites covered the combined surface area of approximately 32.51 km^2 and the total population size of people within the area is about

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30683[17]. The study sites were dominated black ethnical group of the Vhavenḓa tribe and therefore, 99.87% of people in the area speak the Tshivenḓa language[17] (one of South African 13th official language). Nzhelele region is located within the Soutpansberg area, in the northeast of the Makhado Local Municipality (Fig. 1 and Table 1). Therefore, the entire study sites form part of the recognized Soutpansberg endemism center. The vegetation type within the study sites is classified as bushveld of the savanna biome[18]. The area receives an average annual rainfall ranging from 300 mm to 820 mm, with the highest rain received in summer season and the lowest during winter[19]. The geological features of the area include Kalahari Craton, Limpopo Belt, Archaean cratons, Karoo systems and Bushveld Igneas complexity[20].

An ethnobotanical survey was undertaken as from 28 May 2018 to 31 July 2018, in order to document the uses associated with *E. pulvinata* in the region. The total number of 120 participants above the age of 30 years old, were randomly selected and prior informed consent was obtained from each participant. Selected participants included nine traditional healers, herbalists (21), avifaunal hunters (11), subsistence farmers (31) and laypersons (48) (Fig. 2). The interviews were conducted with the participants at the individual level using both semi-structured and close-ended questionnaires in order to allow the flow of ideas and generate the required information from the participants. This was motivated due to the certain beliefs, that traditional healers and herbalists are always secretive when it comes to public sharing of

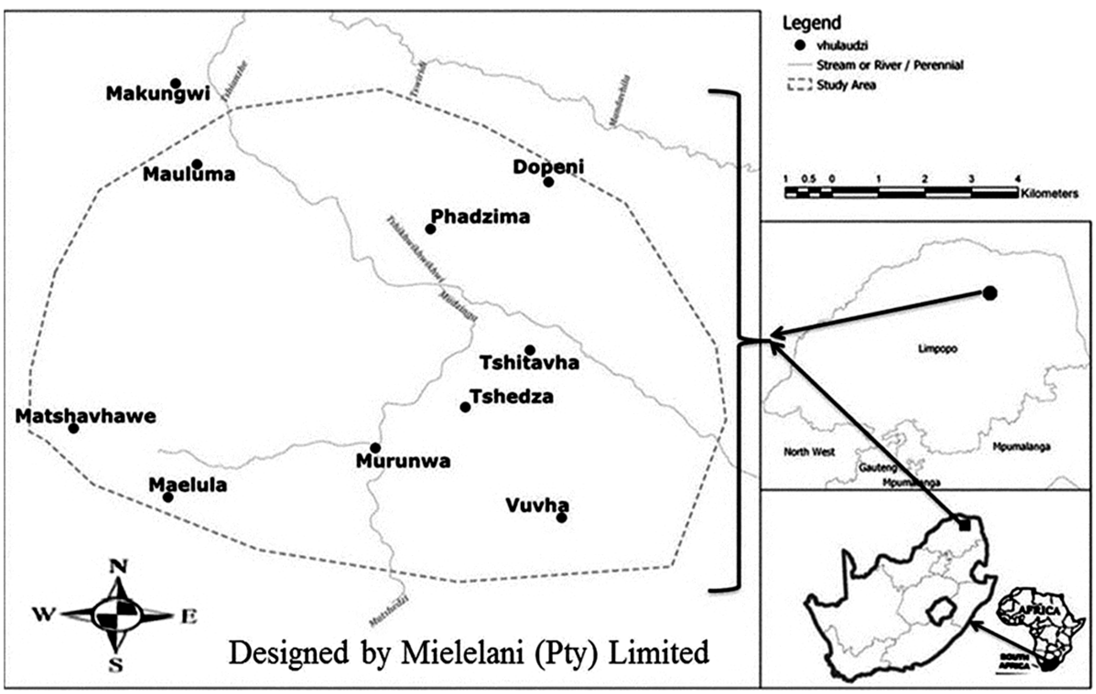

Fig. 1 — Locality map of the study site, Vhulaudzi, Vhembe Biosphere Reserve, Limpopo Province, South Africa.

Table 1 — Geographic coordinates of study sites.

Vhulaudzi subvillages	Latitudes	Longitudes
Muruṅwa village	-22°58′23.31"S; -22°58′55.94"S	30°9′19.89"E; 30°10′1.37"E
Phadzima village	-22°56′14.09"S; -22°57′27.22"S	30°9′35.64"E; 30°12′45.43"E
Tshiṱavha village	-22°57′51.76"S; -22°57′41.67"S	30°10′47.55"E; 30°12′26.35"E
Tshedza village	-22°58′6.77"S; -22°58′28.53"S	30°10′31.56"E; 30°11′41.36"E
Neighboring villages	Latitudes	Longitudes
Ha-Maelula village	-22°58′54.45"S; -22°59′36.26"S	30°7′11.66"E; 30°9′15.74"E
Matshavhawe village	-22°58′17.61"S; -22°59′2.48"S	30°5′41.46"E; 30°6′49.21"E
Mauluma village	-22°55′41.58"S; -22°55′46.49"S	30°8′11.59"E; 30°8′40.02"E
Vuvha village	-22°59′13.26"S; -22°59′39.93"S	30°11′44.13"E; 30°12′34.04"E
Dopeni village	-22°54′55.12"S; -22°55′49.76"S	30°11′2.54"E; 30°12′30.76"E

their information (personal communication with the informants). All questionnaires were administered to participants in Tshivenḓa language understandable by laypersons. During the interview sessions, the same questions were administered to all participants for veracity and validation of the given information. Field inspection surveys were carried out together with participants. Collected ethnobotanical data were stored in the spreadsheet of the Microsoft Office 2010 program and then analyzed using descriptive statistic components such as frequency of occurrence and fidelity level (%). The fidelity level (%) was calculated using the following formula: FL (%) = $N_P/N \times 100$, where FL (%) is the fidelity level percentage; N_P, the number of participants who cited a particular use of *E. pulvinata* and N being the total number of participants who cited any uses of *E. pulvinata*[21]. Because all the participants cited a use of *E. pulvinata*, N was the total number of participants, which is 120.

Results and discussion

Ethnobotanical use

Table 2, delineates the inventory of *E. pulvinata* uses by the Vhavenḓa tribe in Vhulaudzi and its adjacent village areas. The results showed that

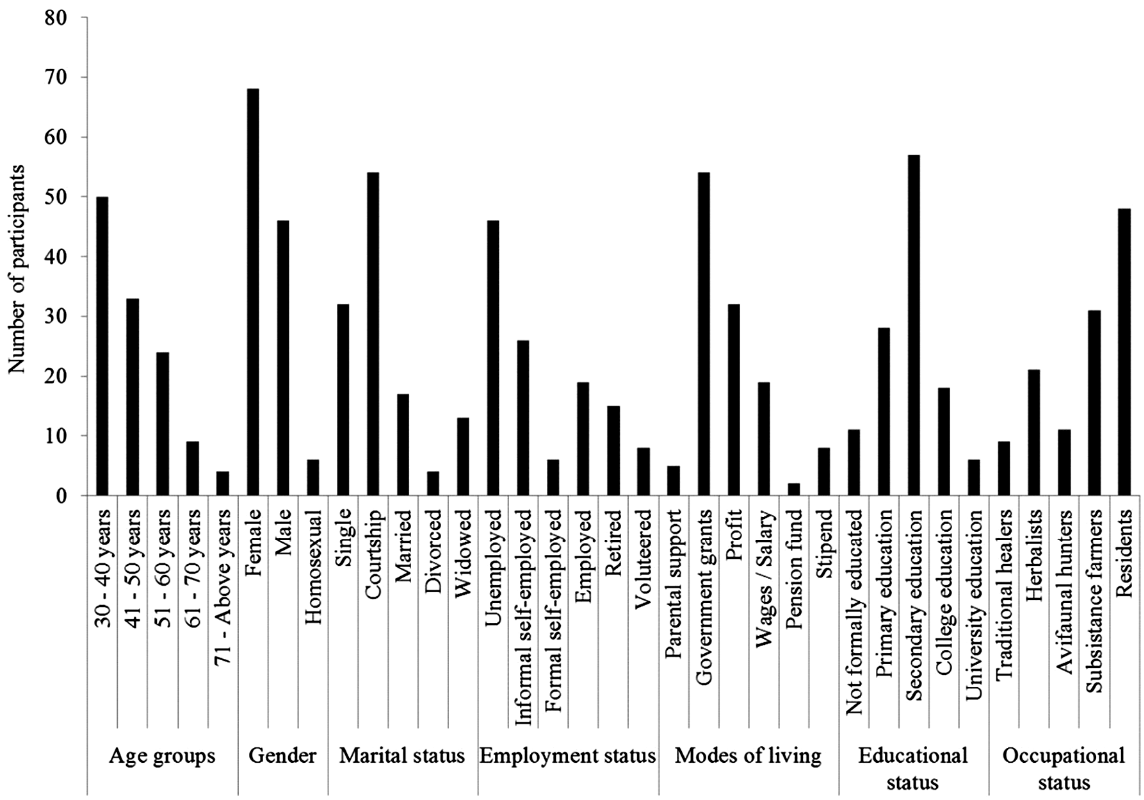

Fig. 2 — Participant's demographic information.

Table 2 — The inventory of uses

Uses categories	Harvested parts	Preparation mode	Frequency (n = 120)	FL (%)	Cited before
Birds-lime	Latex	Boiled and stirred for 20 to 30 minutes	43	35.8	–
Ethnoveterinary medicine	Root	Cooked for 10 to 20 minutes	30	25	–
Insects-lime	Latex	Boiled and stirred for 8 to 16 minutes	21	17.5	–
Ornamental	Whole plant	Grown in the garden	11	9.2	+
Rituals and magical	Thorns and flower	Dried and burned	8	6.7	–
Glue	Latex	Boiled and stirred for 8 to 16 minutes	7	5.8	–

Notes: *E. pulvinata* is locally known as Tshiḓitshinzhi
Keys: FL, Fidelity level; –, Not cited before and +, Cited before[12, 13]

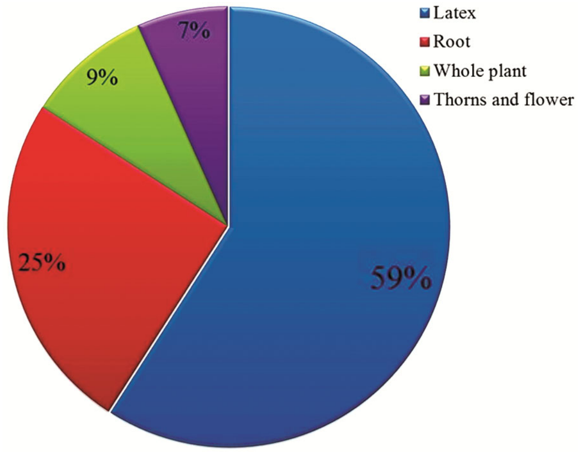

Fig. 3 — Utilization of E. pulvinata parts.

E. Pulvinata was being utilized for various purposes within the study areas. Fidelity level of the six *E. pulvinata* uses ranged from 5.8 to 35.8% (Table 2). Most participants mentioned that they utilized *E. pulvinata* in bird lime making (35.8%), followed by ethnoveterinary medicine (25%), insects-lime (17.5%), ornamental (9.2%), ritual and magical uses making (6.7%) as well as glue making (5.8%) (Table 2). The diverse uses of *E. pulvinata* were encouraged by poverty and high rates of unemployment within the study areas (Fig. 2 and Table 2). This demonstrates the existence of creativity and innovation amongst dwellers in scarce resource village communities of the Vhembe Biosphere Reserve. Therefore, this study argued that creativity and innovations are not optional for dwellers living in scarce resource village communities, but adapted for sustaining their livelihoods. Previous studies have reported that indigenous knowledge about plant uses is not static, but adaptive and dynamic[22-24].

Figure 3 demonstrates the utilization of various *E. pulvinata* parts. Amongst all parts utilized, latex (59%) was the most preferred part used for several purposes, followed by root (25%) used for ethnoveterinary medicine, whole plant (9%) used for horticulture and the least used part were thorns and flower (7%) (Table 2 and Fig. 3). The frequent use of latex in either bird lime-making, insects-lime or glue was enhanced due to its efficacy[21, 25].

Many ethnobotanical studies have demonstrated that leaves are the most frequently used part[26-30]. However, the results in current study do not conform to the previous ethnobotanical studies, since they demonstrated latex as the most frequently used part on *E. pulvinata*. This was because the present study focused on a single plant species, rather many species. The results also signified the unique contribution of the current study in advancing knowledge about uses of *E. pulvinata*.

Conclusion

Regardless of the available alternatives within the study areas, indigenous people still depend on plant resources for their livelihoods. The current study revealed an exceptional insight, regarding ethnobotanical uses of *Euphorbia pulvinata* in Vhembe Biosphere Reserve, South Africa. Five new uses of *E. pulvinata* were recorded in the current study. The newly recorded uses were never reported before in South Africa and elsewhere. This demonstrates the significant contribution of *E. pulvinata* in addressing livelihood and socio-economic challenges in Vhembe Biosphere Reserve. Indigenous knowledge systems still play a pivotal role in advancing understanding about useful biodiversity for human benefits[31]. Further studies on regional re-assessment of *E. pulvinata* 's conservation status or threat detection needs to be done. This baseline study could provide holistic information required for supporting either the upgrade or downgrade of its conservation status at both national and international levels.

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