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

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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 Vonjo 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, RFC: 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; Dzerofos 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 hotspots 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 Tshivenda 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 31º0'00" 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 Archaeal 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 Soutpansberg 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 Bur, and Terminalia prunoides M.A. Lawson, whereas, the some dominant forest plant species include, Xymalos monospora (Harv.) Baille., Kigelia africana L. and Rhodeissus 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).
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 Tshivenda 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
The usefulness of threatened plant species 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 species...
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:

\[ UV_i = \frac{U_i}{N}, \]

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:

\[ RFC = \frac{FC}{N} \quad (0 < RFC < 1). \]

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):

\[ FL(\%) = \frac{N_F}{N} \times 100, \]

Wherein, the FL (%), denote fidelity level of percentage, \(N_F\): 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 Vondo 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 Tshikihawwe 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 Thshivenđa names and this demonstrates their local values. In the Soutpansberg Region, usually, the vernacular names for the folk medicinal plant species used by the Vhavenda ethnic group are associated with the name the ailments that they treat (Personal communication with all the recruits). For example, the Tshivenđa vernacular name of the species *Ocotea bullata* (Burch.) Baill., is called *Mulafha* and it means the malarial healer, with the prefix “Mulafha”, meaning the healer in Thshivenđa language and the suffix “-dali”, meaning the malarial infection. Maroyo 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) | Tshi-gitshinzhi-tsha-Vhusendeka’a | Succulent | -                 | VU                  | Birdlime-making | Latex      | -                 | 0.250 | 0.019 | 1.970  |
| Asparagaceae    | Asparagus sekukunienis (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 Bulb tuber | B1, B2, B3 | 0.0278 | 0.177 | 17.734 |
| Dioscoreaceae   | Dioscorea sylvestri (Eckl.) (RAMLJ 023) | Lurangatshiredzi* | Climber | VU               | VU                  | Ethnoveterinary medicine | - | 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   | Boviera volubilis Harv. ex Hook.f. subsp. volubilis (RAMLJ 015) | Nyalakhobvu | Climber | -                | VU                  | Medicinal and ornamentals | 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 | F1, F2 | 0.063 | 0.079 | 7.882  |
| Ochnaceae       | Brackenridgea zanguebarica Oliv. (RAMLJ 027) | Mutavhatsindi | Tree | -                | CR                  | Medicinal | Barks and root | D, G1, G2, G3 | 0.024 | 0.202 | 20.197 |
| Proteaceae      | Protea laetans L.E.Davidson (RAMLJ 029) | Muphuphadzingu’a | 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’a | Herb | -               | CR                  | Medicinal and ornamentals | Whole plant | H1, H2, H3 | 0.143 | 0.069 | 6.897  |

Key notes: * Vernacular Venda names that had never been recorded before, A: Maroyi (2014), B1: Dludlu et al. (2017), B2: Kunene and Masarirambi (2018), C: Magwede et al. (2019), D: Maroyi et al. (2019b), E: Williams et al. (2013), F1: Ogundajo et al. (2018), F2: Ngubeni et al. (2017), G1: Tiawoun et al. (2019), G2: Tiawoun et al. (2018), G3: Constant and Tshisikhawe (2018), H1: Ullah et al. (2014), H2: Fouche et al. (2013), H3: 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                      | Location              | Plant species location | Coordinates of location | No. of observed sites within the studied region | Observed threats                                                                 |
|-----------------------------------|-----------------------|------------------------|-------------------------|-----------------------------------------------|----------------------------------------------------------------------------------|
| *Asparagus sekukunensis*          | Muruṅwa               | 22°58'59.052" S        | 30°10'28.477" E         | 1                                             | Habitat transformation due to human-settlement and recurring high-intensity fire    |
| *Bowiea volubilis* subsp. volubilis* | Mauluma, Tshipavha, Matshavhawe and Vuvha | 22°56'10.293" S; 22°57'57.953" S; 22°58'26.17 " S; 22°59'34.091 3" S | 30°9'32.992" E; 30°11'27.225" E; 30°7'9.699" E; 30°10'59.016" E | 4                                             | Over-harvesting, invasion by alien plant species                                |
| *Brackenridgea zanguebarica*      | Thengwe               | 22°40'22.325" S        | 30°34'22.659" E         | 1                                             | Over-exploitation due high subsistence and commercial demand                      |
| *Dioscorea sylvatica*             | Tshifhire, Muruņwa and Tshamajangwana | 23°0'19.901" S; 22°59'26.002" S; 22°58'19.423" S | 30°7'52.852" E; 30°9'24.623" E; 30°18'23.864" E | 3                                             | Habitat transformation due to new human-settlement development, invasion by alien plant species and over-harvesting |
| *Encephalartos hirsutus*          | Muruṅwa and Vondo Įa Thavha | 22°59'46.154" S; 22°56'14.813" S | 30°9'25.974" E; 30°21'8.15" E | 2                                             | Over-exploitation due to high commercial demand at both local and international markets |
| *Huernia nouhuysii*               |  ĐoлиDoli             | 22°42'15.742" S        | 30°10'26.554" E         | 1                                             | Recurring drought, invasion by alien plant species and habitat transformation due to new human-settlement development |
| *Ocotea bullata*                  | Tshagowa Mountain, Thathe Vondo | 22°56'18.719" S        | 30°21'8.373" E          | 1                                             | Habitat fragmentation due to pine plantation                                      |
| *Ocotea kenyensis*                | Thethe Vondo Holy forest, and Tshamatingwane | 22°53'6.374" S; 22°58'19.844" S | 30°18'41.363" E; 30°18'15.879"E | 2                                             | Habitat fragmentation due to pine plantation                                      |
| *Protea laetans*                  | Muruņwa Mutshedzi and Muruņwa Maramboni | 22°58'14.937" S; 22°59'13.65" S | 30°18'20.503" E; 30°8'59.46" E | 2                                             | Habitat transformation due to new human-settlement development, recurring high intensity man-made fire |
| *Prunus africana*                 | Khalavha, Tshipangani site and Thathe Vondo, Tshagowa Mountain Valley | 22°55'5.956" S; 22°55'32.456 " S | 30°18'24.894" E; 30°20'46.883"E | 2                                             | Habitat fragmentation due to pine plantation                                      |
| *Rhynchosia vendae*               | Makonde and Ha-Maelula | 22°47'19.536" S; 22°59'9.146" S | 30°33'47.509" E; 30°8'51.234" E | 2                                             | Invasion by alien plant species and habitat transformation due to new human-settlement development |
| *Siphonochilus aethiopicus*       | Thathe Vondo, Tshamatingwane | 22°58'11.676" S        | 30°18'17.197" E         | 1                                             | Over-exploitation                                                               |
| *Warburgia salutaris*             | Ha-Matsa             | 22°50'36.922" S        | 29°59'50.107" E         | 1                                             | Over-exploitation due to commercial demand in local market                        |
The frequently cited useful threatened plant species with UV > 0.024, RFC > 0.059 and FL > 5.911% included A. sekukunensis, 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; Demblé 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 efficacity, 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 Tshisikhawhe 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 Tshisikhawhe (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

![Figure 3](image-url) The number of international and national Red Listed threatened plant diversity
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; Ndhlouv 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 Vondo 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 microclimate 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 22°40'22.325" to 23°0'42.505" South latitudes and 29°59'50.107" to 30°33'47.509" 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
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 Tshamaṱhangwana (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. sekukunienisis*, *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 (Tiwoun 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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REFERENCES

Ahmed N, Mahmood A, Tahir SS, Bano A, Malik RN, Hassan S, Ashraf A. 2014. Ethnomedicinal knowledge and relative importance of indigenous medicinal plants of Cholistan desert, Punjab Province, Pakistan. J Ethnopharmacol 155: 1263-1275.

Al-Qur’an S. 2009. Ethnopharmacological survey of wild medicinal plants in Showbak, Jordan. J Ethnopharmacol 123: 45-50.

Andrade C, Dias PJ, Viana M, Dinis M, Magalhães A. 2011. The Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the Convention on Biological Diversity. Rev Euro Commun Int Environ Law 20: 47-61.

Ceballos G, Ehrlich PR, Dirzo R. 2017. Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. Proc Nat Acad Sci 114: E6089-E6096.

Census. 2011. District Municipality 934 from Census 2011. Available online: https://census2011.adrianfrith.com/place/934 (Accessed on 29 October 2019).

Chambers R. 1994. Participatory rural appraisal (PRA): Analysis of experience. World Dev 22: 1253-1268.

Clark VR, Barker NP, Mucina L. 2011. The Great Escarpment of southern Africa: a new frontier for biodiversity exploration. Biol Conserv 20: 2541.

Cock MJ, van Lenteren JC, Brodeur B, Bigler F, Boldkamins K, Cónsoli FL, Haas F, Mason PG, Parra JR. 2010. Do new access and benefit-sharing procedures under the convention on biological diversity threaten the future of biological control?. Bio Cont 55: 199-218.

Constant NL, Tshishikhae MP. 2018. Hierarchies of knowledge: ethnobotanical knowledge, practices and beliefs of the Vhavenda in South Africa for biodiversity conservation. J Ethnobiol Ethnomed 14: 56.

Cousins JA, Sadler JP, Evans J. 2010. The challenge of regulating private wildlife ranches for conservation in South Africa. Ecol Soc 15: 28.

Crouch NR, Douwes E, Wolfson MM, Smith GF, Edwards TJ. 2008. South Africa’s bioprospecting, access and benefit-sharing legislation: current realities, future complications, and a proposed alternative. S Afr J Sci 104: 355-366.

Czech B, Krausman PR. 1997. Distribution and causation of species endangerment in the United States. Sci 277: 1116-1117.

De Kort H, Prunier JG, Tessier M, Turlure C, Baguette M, Stevens VM. 2018. Interacting grassland species under threat of multiple global change drivers. J Biol 45: 2133-2145.

de Oliveira JP, Balaban O, Dell CN, Moreno-Peñaranda R, Gasparatos A, Iossifova D, Suwa A. 2011. Cities and biodiversity: Perspectives and governance challenges for implementing the convention on biological diversity (CBD) at the city level. Biol Conserv 144: 1302-1313.

De Vos JM, Joppa LN, Gettleman JL, Stephens PR, Pimm SL. 2015. Estimating the normal background rate of species extinction. Conserv Biol 29: 452-462.

Dembélé U, Lykke AM, Koné Y, Témé B, Kouyaté AM. 2015. Use-value and importance of socio-cultural knowledge on *Carapa procera* trees in the Sudanian zone in Mali. J Ethnobiol Ethnomed 11: 14. DOI: 10.1186/1746-4269-11-14.

Department of Trade and Industry. 2017. Special Economic Zone Advisory Board: An Annual Report 2017/2018. Available online: http://www.thedti.gov.za/industrial_development/docs/SEZ_Annual_Repo rt.pdf [1 November 2019]

Dludlu MN, Dlaminli PS, Schindler GF, Vilane VS, Dlaminli CS. 2017. Distribution and conservation status of the endangered pepper bark tree *Warburgia salutaris* (Cannellaceae) in Swaziland. Orx 51: 451-454.

Du Tost MF, Kotze DJ, Illiers AS. 2016. Landscape history, time lags and drivers of change within and around protected areas in a biodiversity hotspot. Land Use Sci 11: 154-176.

Bamgboye S, Tshishikhae MP. 2020. The impacts of bark harvesting on a population of *Encephalartos transvenosus* (*Limpopo cycad*), in Limpopo Province, South Africa. Biodiversitas 21: 8-13.

Bamgboye SO, Tshishikhae MP, Taylor JP. 2017. Detecting threats to *Encephalartos transvenosus* (*Limpopo cycad*) in Limpopo Province, South Africa through indigenous knowledge. Indian J Tradit Knowl 16: 251-255.

Barton JM, Klemd R, Zeh A. 2006. The Limpopo belt: A result of Archean to 348 Proterozoic, Turkic-type orogenesis? Spec Pap-Geol Soc Am 405: 315-332.

Bellard C, Cassey P, Blackburn TM. 2016. Alien species as a driver of recent extinctions. Biol Lett 12: 20150623.

Biró É, Babai D, Bódis J, Molnár Z. 2014. Lack of knowledge or loss of knowledge? Traditional ecological knowledge of population dynamics of threatened plant species in East-Central Europe. J Nat Conserv 22: 318-325.

Boon R, Cockburn J, Douwes E, Govender N, Ground L, Mclean C, Roberts D, Rouget M, Slotow R. 2016. Managing a threatened savanna ecosystem (KwaZulu-Natal Sandstone Sourveld) in an urban biodiversity hotspot: Durban, South Africa. Bothalia-Afri Biol Conserv 46: 1-12.

Brose U, Blanchard JL, Eklof A, Galiana N, Hartvig MR, Hirn M, Kalinka G, Nordström MC, O’Gorman EI, Rall BC, Schneider FD. 2017. Predicting the consequences of species loss using size-structured biodiversity approaches. Biol Rev 92: 684-697.

Bruun HH, Moon J, Virtanen R, Grytnes JA, Oksanen L, Angerbjörn A. 2006. Effects of altitude and topography on species richness of vascular plants, bryophytes and lichens in alpine communities. J Veg Sci 17: 37-46.

Buck M, Hamilton C. 2011. The Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization to the Convention on Biological Diversity. Rev Euro Commun Int Environ Law 20: 47-61.

Czech B, Krausman PR. 1997. Distribution and causation of species endangerment in the United States. Sci 277: 1116-1117.

De Kort H, Prunier JG, Tessier M, Turlure C, Baguette M, Stevens VM. 2018. Interacting grassland species under threat of multiple global change drivers. J Biol 45: 2133-2145.

de Oliveira JP, Balaban O, Dell CN, Moreno-Peñaranda R, Gasparatos A, Iossifova D, Suwa A. 2011. Cities and biodiversity: Perspectives and governance challenges for implementing the convention on biological diversity (CBD) at the city level. Biol Conserv 144: 1302-1313.

De Vos JM, Joppa LN, Gettleman JL, Stephens PR, Pimm SL. 2015. Estimating the normal background rate of species extinction. Conserv Biol 29: 452-462.

Dembélé U, Lykke AM, Koné Y, Témé B, Kouyaté AM. 2015. Use-value and importance of socio-cultural knowledge on *Carapa procera* trees in the Sudanian zone in Mali. J Ethnobiol Ethnemed 11: 14. DOI: 10.1186/1746-4269-11-14.

Department of Trade and Industry. 2017. Special Economic Zone Advisory Board: An Annual Report 2017/2018. Available online: http://www.thedti.gov.za/industrial_development/docs/SEZ_Annual_Repo rt.pdf [1 November 2019]

Dludlu MN, Dlaminli PS, Schindler GF, Vilane VS, Dlaminli CS. 2017. Distribution and conservation status of the endangered pepper bark tree *Warburgia salutaris* (Cannellaceae) in Swaziland. Orx 51: 451-454.

Du Tost MF, Kotze DJ, Illiers AS. 2016. Landscape history, time lags and drivers of change: urban natural grassland remnants in Potchefstroom, South Africa. Landscape Ecol 31: 2133-2150.

Dzeresof CM, Wiikowski ET, Kremér-Köhne S. 2017. Aiming for the biodiversity target with the social welfare arrow: medicinal and other useful plants from a Critically Endangered grassland ecosystem in Limpopo Province, South Africa. Int J Sustain Dev World Ecol 24: 52-64.

Farooq M. 2019. Pioneer community level sympathy of forests of lesser Himalayan belt of upper Tanawal Manshehra, Pakistan. Proc Int Acad Ecol Environ Sci 9: 127-136.

Flax VL, Hameela G, Mofolo I, Hosseinipour MC, Hoffman IF, Mamman S. 2017. Factors influencing postnatal Option B+ participation and breastfeeding duration among HIV-positive women in Lilongwe District, Malawi: A qualitative study. PLoS One 12: e0175590.

Foden W. 2007. South Africa’s threatened species legislation: What stands between our plants and extinction?. S Afr J Bot 73: 288-288.

Fouche G, Van Rooyen S, Faleschini T. 2013. *Siphanochelus aethiopicus*, a traditional remedy for the treatment of allergic asthma. Int J Genuine Tradit Med 3: e6. http://www.e-tang.org/

Gosling A, Shackleton CM, Gambiza J. 2017. Community-based natural resource use and management of Bigodi Wetland Sanctuary, Uganda, for livelihood benefits. Wet Ecol Manag 25: 717-730.
Possingham HP, Andelman SJ, Burgman MA, Medellín RA, Master LL, Keith DA. 2002. Limits to the use of threatened species lists. Trends Ecol Evol 17: 503-507.

Ramarulo LJ, Marooy A, Tshisikhawe MP. 2019a. Asparagus sekukunianisis (Oberm.) Fellingham & N.L.Mey.: A threatened medicinal plant species used by Vhavenda in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa. J Pharm Pharm Sci 9: 080-085.

Ramarulo LJ, Marooy A, Tshisikhawe MP. 2019b. Bowriea volabilis Harv. ex Hook. f. subsp. volabilis: A therapeutic plant species used by the traditional healers in the Soutpansberg Region, Vhembe Biosphere Reserve, Limpopo Province, South Africa. J Pharm Sci Res 11: 2538-2542.

Ramarulo LJ, Tshisikhawe MP. 2019c. Euphorbia pulvinata Marloth: A useful succulent plant species in Vhembe Biosphere Reserve, Limpopo Province, South Africa. Indian J Tradit Knowl 18: 122-126.

Ramarulo LJ, Marooy A, Tshisikhawe MP. 2020. Plant species used for birdlime-making in South Africa. Bangladesh J Bot 49: 117-124.

Rampedi IT, Olivier J. 2013. Traditional beverages derived from wild food plant species in the Vhembe District, Limpopo Province in South Africa. Ecol Food Nut 52: 203-222.

Raustiala K. 1997. Domestic institutions and international regulatory cooperation: comparative responses to the Convention on Biological Diversity. World Pol 49: 482-509.

Raustiala K. 1997. Domestic institutions and international regulatory cooperation: comparative responses to the Convention on Biological Diversity. World Pol 49: 482-509.

Reyes B. 2004. Incorporating anthropogenic threats into evaluations of regional biodiversity and prioritisation of conservation areas in the Limpopo Province, South Africa. Biol Conserv 118: 521-531.

Rossi G, Orsenigo S, Montagnani C, Fenu G, Gargano G, Gargano L. 2005. Conservation: a sustainable model for the management of the global ecosystem services. South Afr J Wildlife Res 35: 291-297.

Schatz GE. 2018. Plants on the IUCN Red List: setting priorities to inform conservation. Trends Plant Sci 23: 521-531.

Schaefder DJ, Arroyo J, Cocucci A, Galetti M, García MB, García D, Gómez JM, Jordano P, Medel R. 2015. Beyond species loss: the extinction of ecological interactions in a changing world. Fun Ecol 29: 299-307.

Valiente-Banuet A, Aizen MA, Alcántara JM, Arroyo J, Cocucci A, Galetti M, García MB, García D, Gómez JM, Jordano P, Medel R. 2015. Beyond species loss: the extinction of ecological interactions in a changing world. Fun Ecol 29: 299-307.

Van Wyk BE. 2015. A review of commercially important African medicinal plants. J Ethnopharmacol 176: 118-134.

Vetaas OR, Grytnes JA. 2002. Distribution of vascular plant species richness and endemism richness along the Himalayan elevation gradient in Nepal. Global Ecol Bio 11: 291-301.

Vhembe District Municipality. 2019. DC 34 Vhembe Final IDP 2017/18-2021/22. https://vhembe.metsimazulu.co.za/resources/129/vhembe-district-municipality [29 October 2019].

Von Glasenapp M, Thornton TF. 2011. Traditional ecological knowledge of Swiss alpine farmers and their resilience to sociocological change. Human Ecol 39: 769-781.

Walsh JC, Watson JE, Bottrill MC, Joseph LN, Possingham HP. 2013. Trends and biases in the listing and recovery planning for threatened species: an Australian case study. Oryx 47: 134-143.

Weber MA, Ringold PL. 2019. River metrics by the public, for the public. PLoS One 14: e0214986. DOI: 10.1371/journal.pone.0214986.

Williams VL, Victor JE, Crouch NR. 2013. Red listed medicinal plants of China. Proc Nat Acad Sci 110: 23-28.

Xu W, Xiao Y, Zhang J, et al. 2017. Strengthening protected areas for biodiversity and ecosystem services in China. Proc Nat Acad Sci USA 114: 1601-1606.