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## Review

## Medicinal plant harvesting, sustainability and cultivation in South Africa

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## ABSTRACT

Concerns regarding the conservation of medicinal plant species are receiving much attention due to over-harvesting and exploitation. Medicinal plant harvesting is a global concern as plants are the source of the majority of medicines, either traditional or western, in the world. Millions of U.S. dollars of plant material are being exported annually from developing countries to developed countries. The challenge in developing countries is that, apart from the exports, the majority of people in those countries still use medicinal plant material for their basic healthcare needs. Biodiversity loss is therefore a significant challenge. This review focuses on South Africa as a developing country in which traditional medicines are highly valued, but also engages in exports of medicinal plant material to developed countries. Medicinal plant harvesting, with reference to suppliers of medicinal plant material, customary knowledge and the drivers of increased harvesting rates in South Africa is discussed. General aspects of sustainability and the causes of unsustainable medicinal plant harvesting, as well as cultivation to increase medicinal plant populations referring to its advantages and disadvantages and the challenges regarding cultivation of medicinal plant species for the medicinal plant trade market are reviewed. The shift from a cultural method of survival to a competitive trade business, South Africa's legislation regulating the management of natural environments, legislation compliance and the regulation of African traditional medicine are also reviewed.

## 1. Introduction

Plants were once the primary source of medicines in the world. Since then, plants continue to provide humans with new remedies as 50% of all drugs in clinical use in the world are derived from natural products, of which higher plants contribute 25% of the total (Van Wyk et al., 2013). Medicinal plants play an integral role in basic healthcare in many developing countries, including South Africa (Fullas, 2007). In developing countries approximately 80% of people use traditional medicines because of its affordability and cultural acceptability (Maroyi, 2013).

South Africa is home to more than 30,000 species of higher plants of which at least 3000 species could possibly be used medicinally (Van Wyk and Gericke, 2007). Authors differ in the number of species that are most actively and commonly used and traded. Mander (1998) reported 700 species commonly used and traded, and Van Wyk et al. (2013) reported only 350 species, which could be an indication of reduced availability between 1998 and 2013, although detail on the species are not available. No statistics are available after 2013 which could serve as an indication of the neglect of monitoring and recording of use and exploitation of medicinal plant species. The majority of plant

material used as traditional medicines is South African indigenous plants harvested from wild resources occurring in grasslands, savannah, forests and thickets. Harvesting includes the collection of either whole plants or plant parts such as roots, bark, flowers, leaves, stems, bulbs and tubers, to treat ailments or to perform rituals (Mander et al., 2007).

The shift from subsistence use to commercial trade in medicinal plants has led to an increase in the frequency of medicinal plants harvested from wild habitats (Van Wyk et al., 2013). All plants, when overharvested are vulnerable to extinction, although medicinal tree species are most vulnerable to harvesting as they are slow-growing, slow-reproducing and many have specific habitat requirements which limit their distribution (Cunningham, 1997). Trees dying as a result of harvesting are therefore not readily replaced. For centuries the sustainable use of medicinal plants was facilitated by several indirect control methods and some intentional management practices. Some of these practices became unused as urbanization and a change in traditional healing practices were experienced.

There are a number of initiatives in South Africa attempting to develop propagation and sustainable production methodologies for continuous sustainable use of medicinal plant material. Funding and coordinated efforts at both provincial and national level, and

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competition for limited resources for housing, sanitation, primary education, basic health care and crime prevention, however, restrict the progress and implementation of effective and sustainable conservation strategies for overexploited medicinal species (Crouch and Smith, 2011). Without financial, resource and human capital support from government, municipalities and the private sector, the valued indigenous knowledge and biodiversity of South Africa will continue to be underutilized and exploited.

## 2. Methodology

Electronic searches of Science Direct and Google Scholar were undertaken to select literature relevant to South Africa and the search was started with search terms “South Africa” and “medicinal plant harvesting” combined with “traditional health practitioners”, “indigenous knowledge” and “trade” for publications dealing with traditional and commercial medicinal plant harvesting and trade. Additional electronic Science Direct and Google Scholar searches using the terms: “medicinal plant harvesting” in combination with “methods”, “commercial harvesters”, “girdling”, “harvesting impacts”, “biodiversity” and “status of bark” were undertaken to search for publications focusing on biodiversity and conservation relating to the different methods of harvesting used by traditional health practitioners and commercial harvesters, the effects of harvesting on biodiversity and the reasons for increased harvesting rates at a global scale. Google searches using the term “South African environmental legislation” were undertaken to search for access to existing South African environmental legislation regarding traditional health practitioners, traditional medicines, forest management, environmental and biodiversity management, protected areas and bio-prospecting. Further Science Direct and Google Scholar searches using the terms “medicinal plant harvesting” combined with “sustainability”, “plant parts” and “quantities harvested” was undertaken for publications in which the sustainability or non-sustainability of medicinal plant harvesting and the principles of a sustainable society are highlighted. Using the term: “cultivation” in combination with “medicinal plants” in Science Direct and Google searches, journals were sought which included information regarding medicinal plant cultivation and the challenges regarding medicinal plant cultivation. Books, dissertations and theses were also consulted on the topics of “medicinal plants”, “indigenous knowledge” “environmental management” and “conservation biology”.

## 3. Results

A total of 366 journal articles, theses, dissertations and books dated between 1970 and 2016 were accessed and consulted on topics pertaining to medicinal plant harvesting, South African legislation, legislation compliance, indigenous knowledge, traditional health practitioners and commercial harvesters, the national and international trade of medicinal plants, biological conservation, environmental management, protected species, sustainability, and cultivation. The literature published between 1970 and 1978 were eliminated. Some of the literature sources between 1978 and 2000 were also considered, even though not recent publications, especially where no new information or statistical data was available. Literature on harvesting and cultivation of medicinal plants in countries other than South Africa were also eliminated for this review. The majority of research on medicinal plant harvesting, sustainability, cultivation and trade in South Africa were conducted, written and published between 1987 and 2016. Literature published after 2016 is extremely limited, which emphasizes the need for updated research and continued monitoring and recording of current trends. Only peer-reviewed publications downloaded from Google scholar and Science Direct were included in the study. South African legislative documents published in the ‘Government Gazette’ were accessed from Google. The department of Forestry and Fisheries (DAFF) mainly publishes statistics on the exports of medicinal plant material.

Data that deal with the imports of medicinal material from neighboring countries are generally not available. Of the 366 references, 60 were thus selected and used as references.

## 4. Discussion

### 4.1. Indigenous knowledge and medicinal plant harvesting

Individual tribes and ethnic communities in different parts of the world preserved different versions of Indigenous or Traditional Knowledge (Bruchac, 2014). In South Africa, the harvesting of medicinal plant material used to be an activity restricted to traditional health practitioners, (Van Andel and Havinga, 2008). Traditional health practitioners are people with no formal medical training, but the communities within which they live recognize them as being competent in dealing with their healthcare needs by using plant, animal and mineral substances (Agbor and Naidoo, 2011).

Indigenous knowledge (IK), such as the knowledge gained by traditional health practitioners over many generations, which includes knowledge on medicinal plants, their uses and methods of application, is the main asset of the poor in the struggle for survival, to produce food and medicines, to provide for shelter and to achieve control of their own lives (Senanayake, 2015). It is the grassroots of decision-making in their communities, and therefore IK regarding natural resources, ecological zones, aquaculture, agriculture, game-management and forestry is more sophisticated than what was previously believed (Senanayake, 2015). Indigenous Knowledge about the identity and the use of medicinal plants has been circulating chiefly among practitioners of traditional medicine or the benefactors of such practices. Localized knowledge and experiences gained through generations, such as the types, distribution, ecology, methods of management and methods of extracting the useful medicinal plants properties are disappearing annually due to lack of written documents, the death of seniors, migration of people due to drought and social problems, urbanization, the influence of modern medicines and the influx of different cultures (Hamilton, 2004; Regassa, 2013).

Traditional health practitioners have stringent traditional values, which include taboos, superstitions, norms and cultural beliefs regarding the harvesting of medicinal plants, and therefore they contributed towards the conservation of medicinal plant species (Williams et al., 2000; Kambizi and Afolayan, 2006). Examples of customary practices that prevented plants from being overexploited included: 1) they only collected plant material after it has been ordained by their ancestors and after performing certain rituals, 2) where the root of a plant is collected for use as medicine, cultural tradition forbids the collection of more than two roots of the same plant at one time, 3) *Trichilia emetica* (Natal mahogany) is, for instance, conserved for their fruit although they are also used in traditional medicine, 4) harvesting of plants such as *Siphonochilus aethiopicus* (African ginger) and *Alepidea amatymbica* (larger tinsel flower) are restricted to winter collection to ensure seed set and multiplication during summer periods, 5) bark that is used for treating kidney diseases are sometimes only harvested from the eastern and western sides of the tree, traditionally resembling the kidneys thereby preventing ring-barking, and 6) plants were collected with a pointed wooden digging stick or small axe which tended to limit the quantity of bark or roots gathered (Kambizi and Afolayan, 2006; Van Wyk et al., 2013). These indirect control measures were often practiced unconsciously (Williams et al., 2000; Kambizi and Afolayan, 2006), while others were purposefully incorporated to conserve the knowledge and plant material ensuring sustainable harvesting. Several of these practices became unused as the harvesting of material, previously exclusively practiced by traditional health practitioners, is now performed by commercial harvesters. These abolished practices resulted in species such as *Siphonochilus aethiopicus* and *Ocotea bullata* (Black stinkwood) facing serious threats of extinction in South Africa. The shift from subsistence use to commercial trade in medicinal plants

and plant parts has led to an increase in the intensity and frequency of medicinal plant harvesting from wild habitats (Geldenhuys and Mitchell, 2006).

In urban as well as rural areas, poverty and a high unemployment rate as result of the economic situation in South Africa, has driven untrained, and often unconcerned people from poor communities to commercial plant harvesting (Williams et al., 2000). Mander et al. (2007) reported more than 200,000 traditional health practitioners in South Africa, as well as an estimated 63,000 commercial harvesters. Contrary to the practices of traditional health practitioners mentioned above, the harvesting methods used by commercial harvesters are environmentally destructive (Grace et al., 2002; Delveaux et al., 2009). For example, medicinal tree bark harvesting is executed by removing the maximum amount of bark and involves the removal of all tissue external to the secondary xylem. When favoured tree species for example, become scarce, gatherers build ladders to maximize the quantity of bark obtained from a tree (Cunningham, 1988). Some large trees are even felled to obtain the bark from the entire length of the tree, and where the bark of large trees have been depleted, juvenile trees are being stripped for their bark (Chungu et al., 2007). Increasing scarcity of certain plant species is of no concern to either gatherers or traders of medicinal plants. For traders increasing scarcity of medicinal plant species means higher prices, which increases their profit margin (Cunningham, 1988), and for gatherers higher prices acts as incentive for increased harvesting rates (Cunningham, 1993). The generally low prices paid to commercial harvesters also force them to increase harvesting to generate a reasonable income (Monakisi, 2007). Traders only become concerned about scarcity of medicinal plants when the diversity of plant material available in their shops are affected, as the unavailability of certain scarce species or plant parts could result the cancellation of the whole order placed by a client (Cunningham, 1988). A concerning matter for conservationists is that fewer traditional health practitioners harvest plant material themselves as they now purchase from commercial harvesters. This is particularly true for traditional health practitioners practicing in cities as the cities are often several hundred kilometers away from available resources (Mander, 1998). Commercial harvesters from both urban and rural areas perceive plants as a common property resource, and there are no or little incentives for resource management or traditional conservation practices (Dold and Cocks, 2002).

Many of South Africa's medicinal tree species are multi-purpose species and are thus not used only for medicinal purposes (Van Wyk and Gericke, 2007). Multi-purpose tree species are more vulnerable to extinction than single-use species because of their many uses and thus require strict regulation by law, as well as intensified conservation interventions (Primack, 2012). Examples of a few such tree species in South Africa are shown in Table 1.

#### 4.2. Pressure on natural resources and trade

In the last 150 years the world's human population increased from 1

billion in 1850 to the more than 7 billion (Keinan and Clark, 2012). South Africa's human population increased from 40.58 million in 1996 (Statistics South Africa, 1996), to 56.12 million recorded in March 2018 (South Africa, 2018). The persistent increase in the number of humans on earth resulted in an increase in the demand for medicinal plants and plant products. Urbanization and the subsequent expansion of urban areas, ongoing infrastructure development, overgrazing, over-exploitation and clearing of natural areas for mining, agriculture and forestry (Cunningham, 1988; Primack, 2012), on the other hand, reduces availability medicinal plants in natural areas, which puts increasing pressure on resources (Sibly and Hone, 2002).

The growing South African population and the migration of people from rural to urban areas over time resulted in the establishment of a competitive medicinal plant trade market, especially in larger cities (Williams et al., 2000; Dold and Cocks, 2002; Botha et al., 2004a). The trade in medicinal plants occurs on three levels (Kuipers, 1997). On the first level, medicinal plant species are traded nationally, can include hundreds of species and trade is usually undertaken at regional medicinal plant markets. The second level is the informal trade of medicinal plant material across national borders but within the same continent. Trade consists of fewer species and usually consists of rare and/or threatened species. The third level comprises the formal international export trade and a high number of species are being traded at significant volumes. Mander et al. (2007) reported that the trade in raw plant material was estimated to be R520 million per annum in 2006 (approximately \$74.25m at 2006 exchange rates when the exchange rate averaged R7.00 to the US dollar), and that traditional health practitioners prescribed an estimated additional R2.6 billion (approximately \$371.4m at 2006 exchange rates) of plant material. Mander et al. (2007) further stated that the value of the total medicinal plant product trade in South Africa is worth an estimated R2.9 billion per year (approximately \$414.2m at 2006 exchange rates). Most of this value, however, did not enter the formal trade, which is therefore an addition to South Africa's Gross Domestic Product (GDP). The South African Department of Forestry and Fisheries (DAFF) reported that South Africa exported 6497 tons of medicinal plant material in 2015, compared to the 1143 tons in 2014. Of the 6497 tons exported in 2015, 6028 tons were exported to Europe, 387 tons to America. 58 tons to other African countries and 24 tons to Asia (DAFF, 2016). Information regarding trade to South Africa from neighboring countries such as Botswana, Zimbabwe and Mozambique is not available, although important to understand the supplementation of plant material in South Africa.

#### 4.3. South African environmental legislation

Many countries implement legislation in protection of their biological resources. In South Africa, the original environmental laws were revised after the birth of the new political dispensation in 1994 (Constitution of South Africa Act 108 of 1996) (South Africa, 1996). South Africa implemented acts such as the National Environmental

**Table 1**

Examples of South African indigenous tree species of which plant parts are used medicinally and the alternative uses of those species (Van Wyk and Gericke, 2007; Venter and Venter, 2012).

Species	Plant part used medicinally	Alternative uses
<i>Vachellia karroo</i> (previously known as <i>Acacia karroo</i> )	Bark	Bark used for tanning and for making ropes. Seeds roasted and used as alternative to coffee.
<i>Acacia xanthophloea</i>	Bark	Wood used for general purpose carpentry.
<i>Dalbergia melanoxylon</i>	Roots	Wood is black and used for producing ornaments, walking sticks and wood wind musical instruments such as oboes and clarinets.
<i>Dombeya rotundifolia</i>	Bark, roots and wood	Wood used to make implement handles and ornaments. Bark fiber used to make ropes.
<i>Ekebergia capensis</i>	Bark, roots and leaves	Wood used to make furniture.
<i>Elaeodendron metabelicum</i>	Bark	Wood used for carved items. Root bark yields a yellow dye.
<i>Myrsine melanophloeos</i> (formerly known as <i>Rapanea melanophloeos</i> )	Bark	Wood used for superior furniture and for making violins.

Management: Biodiversity Act 10 of 2004 (NEMBA) (South Africa, 2004), to comply with its obligations as a party to the Convention on Biological Diversity (CBD) in 2015 (Crouch et al., 2008). NEMBA, the National Biodiversity Strategy and Action Plan (NBSAP) and the National Biodiversity Framework (NBF) were implemented to envisage the sustainable use and conservation of biological resources (Crouch et al., 2008; Crouch and Smith, 2011). The National Environmental Management: Protected Areas Act 57 of 2003 (NEMPA) (South Africa, 2003), provided for, and facilitated access to natural resources where it has been prohibited before, but with focus on the principle of sustainability (Vermeulen, 2009). The principles of a sustainable society are extensively described by Munro and Holdgate (1991). NEMBA (South Africa, 2004) Notice on Bioprospecting, Access and Benefit-sharing Notice 329 of 2007 (South Africa, 2007a) also published draft regulations on bioprospecting and access, as well as benefit sharing to protect IK (Vermeulen, 2009). The National Forests Act 84 of 1998 (NFA) (South Africa, 1998), protects South African forests and trees through a licensing system where: “no person may without a license collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree” (Strydom and King, 2013). The act, however, provides for exceptions in favour of use of natural resources and exempts local communities from its licensing provisions: “if the intention for the activity is for domestic, cultural, health or spiritual purposes”, but the exemptions do not include the use of species that are listed as protected (Strydom and King, 2013). Additionally, traditional health practitioners in South Africa gained recognition in the late 1990s and the Traditional health practitioners Act 22 of 2007 (South Africa, 2007b) was therefore assented to on 8 January 2008 (Le Roux-Kemp, 2010). South Africa does not have an integrated legislative framework or an appropriate regulatory regime for African traditional medicine. Currently, there are difficulties with the registration of African traditional medicine and complimentary medicines due to delays with drawing up of appropriate regulations. (South Africa, 2008).

A draft policy on African traditional medicine for South Africa Notice 906 of 2008 (South Africa, 2008) acknowledged the need for: 1) official support and acceptance of traditional medicine in the formal healthcare sector, 2) establishment of a system to regulate, register and license traditional health practitioners and the formal training of such practitioners, 3) the establishment of a system to develop, regulate and register traditional medicine to ensure safety, quality and efficacy, including scientific research, 4) the development of a national pharmacopoeia or the updating of existing ones as part of the regulatory system, and 5) collaboration with other countries and the World Health Organization (WHO) in order to exchange information and promote policies and regulation according to international standards (South Africa, 2008).

The draft policy on African traditional medicine Notice 906 of 2008 (South Africa, 2008) stated that institutionalization of African traditional medicine should take place, among others, the following actions: 1) policy finalization and adoption, 2) the establishment of a National Institute of African Traditional Medicine for South Africa (ATMSA), 3) protecting traditional health practitioners and the users of traditional medicine against unqualified or incompetent individuals selling medicine and/or acting as traditional health practitioners, 4) protection of African traditional medicine knowledge and intellectual property rights, 5) conservation of medicinal plants and animals and counteracting unsustainable harvesting practices, 6) development of acceptable standards of safety and quality for African traditional medicines and raw materials, 7) establishment of an African traditional medicine pharmaceutical industry for the production and processing of African traditional medicine to ensure a sustainable supply of high quality, affordable products, and 8) education of street vendors regarding sanitation, conservation and harvesting of medicinal plants. It is clear however, that within the last decade, very little progress was made on realizing these important aspects and improving the traditional medicine sector.

Additionally, according to the Draft policy on African traditional medicine for South Africa. Notice 906 of 2008 (South Africa, 2008) the most challenging aspect faced with before the draft policy can be finalized, is the application of the Patent Amendment Act (Act 20 of 2005) (South Africa, 2005) to traditional medicine. The knowledge of traditional medicine has been passed down within the context of a defined communal system without any identifiable creator or inventor. Where a traditional health practitioner may wish to patent his/her knowledge, he/she may have difficulty in proving his/her novelty. If it is a plant-based medicine it is not patentable as natural material, such as plants, are not patentable without processing. More problematic is that no method of treatment of human or animal body or surgery is patentable. Lack of written records creates difficulties in terms of international protection as patent offices in other countries are not able to access such information for the purpose of establishing its novelty and inventiveness. It is apparent that given the nature and content and practice of African traditional medicine, it is unsuitable to be protected by current legislation (South Africa, 2008). McGaw et al. (2005) suggested that the type of rights Africa needs are not intellectual property rights monopolised through privatisation, but rights that support local communities and indigenous people.

The environmental laws, both prior to democracy in 1994 and the new environmental laws promulgated and implemented thereafter, has failed to prevent the illegal harvesting and trade in South African indigenous plants and plant parts (Botha et al., 2004a). With the old environmental laws, medicinal plants were unprotected, and destructive harvesting from natural resources was thus practiced in destructive quantities. This included a loss of biological resources, benefits to the country, as well as losses to the holders of IK and their communities (Crouch et al., 2008). Both previous (pre-1994) and current legislation (post-1994) also failed to prevent the exploitation and sale of protected plants and plant parts, the sale of toxic species such *Callilepis laureola*, the sale of poisonous substances such as potassium bichromate and the practicing of unlicensed herbalists and diviners (Cunningham, 1988; Le Roux-Kemp, 2010). Cunningham (1993) pointed out that legislation merely slowed down the rate of increase in exploitation without providing any solution. The Traditional health practitioners Act (Act 22 of 2007), states that: “no person may practice as a traditional health practitioner within the Republic of South Africa unless he or she is registered in terms of the Act”, however, Le Roux-Kemp (2010) stated that very few traditional health practitioners are registered with the Traditional Healer's Association. Le Roux-Kemp (2010) also indicated that although the Traditional health practitioners Act (Act 22 of 2007) regulates traditional medical practices, the medicines sold by them are not appropriately registered with the Medicines and Related Substances Control Act (Act 101 of 1965) (South Africa, 1965), and are therefore sold without any control.

#### 4.4. Sustainability

At the starting point of the ecosystem approach to sustainability lies the recognition that humans form an integral part of ecosystems. The one is therefore dependent on the other. When utilization occurs in such a manner that both the human condition and the ecosystem condition are stable or improving, then a society can be regarded as sustainable. A sustainable harvest approach needs to take four interlinked measures into account: 1) the landscape, 2) the communities and ecosystem, 3) the plant populations, and 4) genetic diversity (Schippmann et al., 2002b).

For any plant resource, there is a relationship between resources stock, population size and sustainable harvesting rates. Low stocks produce low yields, especially if the plant species is slow-growing and reproduction rates are low (Cunningham, 1997). The plant parts harvested determines the survival of the plant after harvesting. Where bark, roots or whole plants are harvested, the plant generally dies. The harvesting of leaves, flowers, fruits and seeds are considered less

destructive, however, severe pruning affects a plant's vigour and reproductive potential (Grace et al., 2002; Van Andel and Havinga, 2008). The vegetation type from which the plants or plant parts are collected, their abundance and growth rates determine sustainable rates of harvesting. In general, the regeneration rate after harvesting will determine how much can be used sustainably (Delveaux et al., 2009). Tolerance to plant part harvesting varies with climatic conditions and depends on the resources available to stimulate growth and recuperation (Ticktin, 2004). For many countries and many plant species, information on how much plant material constitutes sustainable harvesting is totally lacking (Van Andel and Havinga, 2008), because research on the conservation and sustainable use of medicinal plants and their habitats has fallen far behind the demand for this globally important resource. Each species has unique ecological, socio-economic, health and cultural associations that must be understood. (Schippmann et al., 2002b). Vermeulen (2009) stated that the development of yield systems and best practices for harvesting can only be achieved through controlled, experimental harvesting and long-term monitoring.

In the early 2000s, approximately 20,000 tons of plant material are harvested from wild resources annually for the local medicinal plant trade market in South Africa (Mander et al., 2007). These volumes exclude the quantities harvested for the export market. An additional 40 tons of scarce species are imported from neighboring countries such as Mozambique and Swaziland, while only 5 tons are harvested from cultivated plants (Mander, 1998; Mander et al., 2007). The annual volumes harvested for the local medicinal plant trade market may vary slightly depending on demand and availability. Mander et al. (2007) lists the percentages of the plant parts traded in South Africa as: 27% roots, 27% bark, 14% bulbs, 13% whole plants, 10% leaves and stems, 6% tubers, and 3% mixtures of plant parts. Several authors reported that rates of harvesting in South Africa are unsustainable (Mander, 1998; Botha et al., 2004a; Kambizi and Afolayan, 2006; Van Andel and Havinga, 2008), and Botha et al. (2004a) reported that increased pressure on habitats resulted in numerous local extinctions. Due to the lack of recent studies and statistics, the situation might have significantly deteriorated from 2007 and earlier reports, and stress the importance of an integrated regulatory system.

Causes of unsustainable harvesting in general, are listed by Maundu et al. (2006), Strydom and King (2013), Regassa (2013) and Cunningham (1997) as: 1) A high global population growth rate, 2) competing land uses, 3) environmental degradation, 4) loss of indigenous knowledge, 5) increasing commercialization of traditional medicine, 6) increasing demand in the local and world markets, 7) lack of appropriate policies and legislation and/or the failure to enforce them, 8) poverty and high unemployment, 9) low prices paid for medicinal plants, 10) invasive alien plants which pose a threat to indigenous plant diversity, 11) the use of unsustainable methods of harvesting, 12) undue pressure on specific preferred species, and 13) the slow plant growth, especially that of medicinal tree species. Maundu et al. (2006) also described 3 key effects of unsustainable harvesting: 1) local or global extinctions, 2) narrowing of the genetic pool, and 3) weakening regeneration potential.

With the rapidly declining medicinal plant populations, the explosive increase in the human population and the remaining medicinal plant populations, especially plants where roots and bulbs and slow-growing, slow-reproducing medicinal tree populations already over-exploited by injudicious harvesting, are affected, it may be speculated whether harvesting could be sustainable from the remnant medicinal plant populations, even if sustainable methods of harvesting are used.

#### 4.5. Cultivation of medicinal plant species

With the increased realization that wild medicinal plant populations are being overharvested, several agencies such as the World Health Organization (WHO), the International Union for the Conservation of

Nature (IUCN) and the World Wide Fund (WWF) recommended that wild species be brought into cultivation systems (Schippmann et al., 2002a).

Due to several challenges, large scale cultivation of medicinal plant material for the medicinal plant trade has not been undertaken since first suggested by Gerstner in 1938 (Cunningham, 1988). The implementation of environmental legislation in South Africa is challenging due to the shared responsibility between national and provincial governments. This has led to fragmented implementation. The implementation of conservation laws is also limited by the government's willingness and ability to act against those who fail to comply with the law (Strydom and King, 2013). In South Africa there are three main reasons for the lack of cultivation of medicinal plants species, the reasons being: 1) the lack of institutional support for the production and dissemination of key species for cultivation, 2) the low prices paid to plant material harvesters by herbal traders, and 3) many important medicinal species take a long time to mature (Cunningham, 1997). If cultivation of medicinal plant material is to be successful in providing an alternative supply in herbal medicines to reduce harvesting pressure on wild stocks, then plants need to be cultivated cheaply and in large quantities. Already in the 1990s it was stated, that if cultivation does not take place on a scale large enough to meet annual market demand, cultivation will only mask the continued exploitation of wild resources (Cunningham, 1997).

Land area needed for cultivation is related to demand, plant size and the growth rate of the plants. For example: bulbous plants can be planted relatively densely and rotation can be between six and 10 years, thus the rotational area would be relatively small, whereas trees need much more land area for healthy root growth and development. Their rotational area would thus be far greater, especially if the slow-growing nature of South Africa's indigenous trees is taken into account (Cunningham, 1988).

Many people in rural communities believe in the risk of metaphysical dangers destroying the healing power of *amayeza* (isiXhosa for medicine),<sup>1</sup> and this belief has repercussions in respect to the acceptance of cultivated medicinal plant material. They believe that *amayeza* is highly susceptible to losing their effectiveness when touched by "polluted people" (Wiersum et al., 2006). For conservationists there is a continuous concern about the acceptance of cultivated medicinal plants, as cultivated material is believed to lack the (spiritual) 'power' of healing (Cunningham, 1993). Although cultivated medicinal plant material is accepted as an alternative in countries such as Swaziland, Botswana and Ghana, conservative traditional health practitioners in South Africa believe that plants cultivated using western ways of cultivation (i.e. with fertilizers and in straight rows) will not have the same healing properties as those harvested from wild populations (Fennel et al., 2004). Substantiation for this belief has already been disclosed in this statement as factors such as season, irrigation and fertilization of material has resulted in altered medicinal activity of cultivated material (Prinsloo and Nogemane, 2018). Bioactive compounds in fast growing cultivated stock may be lower than the bioactive compounds in wild populations because wild populations may be older due to slow growth (Schippmann et al., 2002a). It was found, however, that people's beliefs regarding cultural uses of medicinal plants and plant parts are more important than their concerns regarding the possible lack of potency of cultivated plants. This led to an increase in the demand for cultivated medicinal plants (Wiersum et al., 2006).

Planting *amayeza* species in a separate and secluded place in a home garden, however, was perceived as a viable approach in reducing the risk of contact with polluted people. The majority of people questioned by Wiersum et al. (2006) stated that they would use cultivated material

<sup>1</sup> IsiXhosa is one of the 11 official languages in South Africa and is mostly spoken by African people in the Eastern and Western Cape provinces of South Africa.

for healing or protection purposes. Home garden cultivation is, however, hindered by lack of water for irrigation, as well as difficulties with propagation and lack of experience with proper cultivation requirements such as soil and light conditions (Wiersum et al., 2006).

From a market perspective, cultivation provide a number of advantages over wild stocks for the production of plant-based medicines (Schippmann et al., 2002a). The advantages are: 1) material collected from the wild and sold in street markets or muthi shops (muthi is the isiZulu word for medicine)<sup>2</sup> are often adulterated with unwanted, harmful plant species to enhance potency, while cultivated provides reliable botanical identification, 2) provide a steady source of raw material, 3) wholesalers and pharmaceutical companies can agree on volumes and prices with the grower, 4) controlled post-harvest handling and therefore appropriate quality control, 5) standards can be adjusted to regulations and consumer preferences, 6) possibility of implementing product certification, and 7) allows for the production of homogenous material, therefore guaranteeing chemical homogeneity while preserving species threatened with extinction (Rates, 2001).

Cultivation may be difficult for some species due to certain biological features or ecological requirements such as slow growth rate, soil and water requirements, low germination rates, susceptibility to pests, etc. (Schippmann et al., 2002b; Rao et al., 2004). The main rationale for cultivation is economic feasibility, but it is also a limitation. Cultivated stock will compete with stocks collected from wild populations at the trade markets as commercial harvesters harvesting their material from wild populations have no input costs. Due to low prices, only a few species could thus be marketed at high enough prices to make cultivation profitable. (Schippmann et al., 2002a). Cultivation for profit is therefore restricted to a small number of high priced and or fast growing species destined for a specific commercial market. There is constant competition against cheap plant material harvested from the wild with little or no expenses for the gatherers. Although some species, such as *Siphonochilus aethiopicus* and *Warburgia salutaris* (pepper bark tree) became extinct or threatened in the wild (Botha et al., 2004b), low prices ensure that few slow growing species are cultivated (Cunningham, 1993). *Siphonochilus aethiopicus*, a plant with rhizomatous roots, is easy to propagate and cultivate and is successfully cultivated in the warm parts of South Africa (Van Wyk, 2008). Cultivation of wild ginger should be a financially viable operation in South Africa since there is always a demand and the income generated justifies the effort. Street traders obtained up to R140/kg (approximately \$16.09/kg at 1997/1998 exchange rates which averaged at R8.70 to the dollar), while shops and healers obtained a price of up to R450/kg (approximately \$51.72/kg) in 1997/1998 (Mander, 1998). Prices for these products may be much higher at present, however, a lack of data between 1998 and 2018 emphasizes the need for updated research on this topic. To make this a viable option, plants must be produced cost effectively.

Several examples of South African medicinal plants being cultivated to meet rising demand exist. As demand increase globally the only viable solution for meeting demand is sustainable production. *Agathosma betulina* (buchu), *Aloe ferox*, *Hypoxis hemerocallidea* (African potato) and *Harpagophytum procumbens* (Devil's claw) to mention a few, receive commendable attention internationally as it is introduced to more markets globally. Buchu has been wild-harvested at least since 1820 and cultivated since the 1970s or perhaps even earlier (Van Wyk, 2011) and until 1995 most of material was wild harvested and not cultivated. Buchu is used in various applications and processed into oil. Extracts and dried leaves and powdered buchu is used for medicinal and cosmetic purposes as well as flavouring agents in the food industry (Van Wyk et al., 2013; Moolla and Viljoen, 2008). Lubbe and Verpoorte (2011) reported the price of Buchu at around R600/kg (about \$40/kg)

<sup>2</sup> IsiZulu is also one of the 11 official languages in South Africa and is mostly spoken by African people in the KwaZulu-Natal province of South Africa.

for cultivated material which makes it an excellent crop for small-scale farming to provide an income.

Cultivation may benefit some farmers of medicinal plant material in rural communities in that they will be able to generate an income, as both males and females are equally involved (Wiersum et al., 2006). This might also create an unfavourable situation if cultivation expands to the point that outsiders with capital come in and develop large-scale monocultural plantations for export markets, rural people may benefit from plantations only as a result of available employment and hence off-farm income. Large plantations of medicinal plants established by rich and influential people may alter market forces to their advantage by imposing low wages which will restrict the social and economic development of local people. The major beneficiaries of large-scale exports will thus only be the country's elite and the national economy (Schippmann et al., 2002a). Schippmann et al. (2002a) also disclosed that those socially disadvantaged groups who actually depend on gathering traditional medicine for their survival and cash income may not have access to farm land, and are therefore not able to compete with large-scale production of medicinal plants by well-established farmers.

For threatened medicinal plant species cultivation is a conservation option since the constant harvesting of material from wild populations is much higher than the annual sustained yield. If the demand for these species can be met from cultivated sources the pressure on the wild populations will be relieved. It will however not increase genetic diversity. The need for strict conservation of remaining wild populations, improved ex situ security of genetic material of germ cells and investment in selection and improvement programmes are therefore extremely urgent (Schippmann et al., 2002a).

## 5. Conclusion

A large percentage of the people in South Africa still rely on medicinal plants for their primary health care, and increasing population numbers and increasing competition for land are barricading the survival of medicinal plants for use by future generations. There are many recommendations aiming at increasing the number of medicinal plants for use. Probably the most important of these is the option to cultivate and commercialise medicinal plants. This could be incorporated into commercial farming opportunities, but also small scale farmers and homestead gardens. The challenge lies within the cost of production measured against the comfort and no costs of harvesting from wild populations. Farming is associated with numerous risks and a struggling agricultural sector does not guarantee an increase in farming opportunities for medicinal plants. The challenges that South African economy is facing, is favouring production of more specialised and stabilized crops with established markets. There is, however, a need for alternative supply of medicinal plant material as wild populations are struggling under the pressure of increased demands. The only option for many species is cultivation on such a scale that it becomes financial viable. It is also important to realize that many of the declining medicinal plant species are plants that are slow to reach maturity, thereby increasing the cost of production significantly. This complicates the situation of a financial viable option of farming with medicinal plants. There are however several initiatives in the country, supported by provincial governments and municipalities attempting to develop effective propagation methods for declining species, and investigating the effects of cultivation on the biological activity of medicinal plants. Funding, resources and human capital is however one of the major obstacles in gathering more information and initiating research. The slow progress in development of quality standards, registration of medicine and traditional health practitioners, development of safety standards and pharmacopoeia and investment of the pharmaceutical industry are all challenges still faced by the country, even though legislation and regulation is envisaged to promote this sector. The large number of plants available in the country, and the large number of plants used as medicines certainly must be regarded as important

aspects for future strategic research initiatives. The progress of research in the field of developing effective quality assessment tools, good agricultural practices (GAP) and developing pharmacopoeia for important medicinal species are too slow to support large scale incorporation of new crops onto the market. Without financial, resource and human capital support from government, municipalities and the private sector, the valued traditional knowledge of our plants will disappear with the plants. Many research strategies such as those involving bioprospecting of medicinal plants need serious support from these structures to ensure financial gain in future. With the support and encouragement needed from the various stakeholders, ethnobotanical information and the rich biodiversity in the country could be transformed into financial benefit for many struggling enterprises in South Africa.

## References

- Agbor, A.M., Naidoo, S., 2011. Knowledge and practice of traditional health practitioners in oral health in the Bui division, Cameroon. *J. Ethnobiol. Ethnomed.* 7 (6) (8 pp.).
- Botha, J., Witkowski, E.T.F., Shackleton, C.M., 2004a. Harvesting impacts on commonly used medicinal tree species (*Catha edulis* and *Rapanea melanophloea*) under different land management regimes in Mpumalanga, Lowveld, South Africa. *Koedoe* 47 (2) (18 pp.).
- Botha, J., Witkowski, E.T.F., Shackleton, C.M., 2004b. The impact of commercial harvesting on *Warburgia salutaris* ('pepper-bark tree') in Mpumalanga, South Africa. *Biodivers. Conserv.* 13, 1675–1698.
- Bruchac, M., 2014. Indigenous knowledge and traditional knowledge. In: Smith, C. (Ed.), *Encyclopedia of Global Archaeology*, pp. 3814–3844. Available from: [https://repository.upenn.edu/cgi/viewcontent.cgi?article=1172&context=anthro\\_papers](https://repository.upenn.edu/cgi/viewcontent.cgi?article=1172&context=anthro_papers), Accessed date: 7 June 2018.
- Chungu, D., Muimba-Kankolongo, A., Roux, J., Malambo, F.M., 2007. Bark removal for medicinal use predisposes indigenous forest trees to wood degradation in Zambia. *S. Hem. For. J.* 69 (3), 157–163.
- Crouch, N.R., Smith, G.F., 2011. Informing and influencing the interface between biodiversity science and biodiversity policy in South Africa. *Bot. J. Linn. Soc.* 106, 301–309.
- Crouch, N.R., Douwes, E., Wolfson, M.M., Smith, G.F., Edwards, T.J., 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.
- Cunningham, A.B., 1988. An investigation of the herbal medicine trade in Natal/Kwazulu. In: *Investigational Report No. 29*. Institute of Natural resources, Pietermaritzburg (153 pp.).
- Cunningham, A.B., 1993. Setting priorities at the interface between conservation and primary healthcare. In: *African Medicinal Plants. People and Plants Working Paper to United Nations Educational, Scientific and Cultural Organization (UNESCO)* 53 pp. Available from: [citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.294.2667&rep&type=pdf](http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.294.2667&rep&type=pdf), Accessed date: 21 September 2015.
- Cunningham, A.B., 1997. An Africa-wide overview of medicinal plant harvesting, conservation and health care. In: Bodeker, G., Bhat, K.K.S., Burley, J., Vantomme, P. (Eds.), *Plants for Forest Conservation and Health Care. Food and Agricultural Organization of the United Nations (FAO)*, pp. 116–129. Available from: [www.fao.org/3/a-w7261e.pdf](http://www.fao.org/3/a-w7261e.pdf), Accessed date: 21 September 2015.
- Delveaux, C., Sinsin, B., Darchambeau, F., van Damme, P., 2009. Recovery from bark harvesting of 12 medicinal tree species in Benin, West Africa. *J. Appl. Ecol.* 46, 703–712.
- Department of forestry and Fisheries (DAFF), 2016. A Profile of the South African Traditional Medicines Value Market Chain. 42 pp. Available from: [www.nda.agric.za/daoDev/sideMenu/Marketing/Annual20%Publications/Commdity%20Profiles/field%20crops/Medical%20Plants%20Market%20Value%20Chain%20Profile%202016%20-%20Copy.pdf](http://www.nda.agric.za/daoDev/sideMenu/Marketing/Annual20%Publications/Commdity%20Profiles/field%20crops/Medical%20Plants%20Market%20Value%20Chain%20Profile%202016%20-%20Copy.pdf), Accessed date: 17 April 2018.
- Dold, A.P., Cocks, M.L., 2002. The trade in medicinal plants in the Eastern Cape Province, South Africa. *S. Afr. J. Sci.* 98, 589–597.
- Fennel, C.W., Light, M.E., Sparg, S.G., Stafford, G.I., van Staden, J., 2004. Assessing African medicinal plants for efficacy and safety: agricultural and storage practices. *J. Ethnopharmacol.* 95, 113–121. <https://doi.org/10.1016/j.jep.2004.05.025>. (Retrieved: 23 August 2017).
- Fullas, F., 2007. The status of African medicinal plants and their future. *Afr. Renais* 4 (3/4), pp102–112.
- Geldenhuys, C., Mitchell, D., 2006. Sustainable harvesting technologies, a South African guide. In: Diederichs, N. (Ed.), *Commercialising Edible Plants*. Sun Press, Stellenbosch, pp. 23–39.
- Grace, O.M., Prendergast, H.D.V., van Staden, J., Jäger, A.K., 2002. The status of bark in South African health care. *S. Afr. J. Bot.* 68, 21–30.
- Hamilton, A., 2004. Medicinal plants, conservation and livelihoods. *Biol. Conserv.* 13, 1477–1517.
- Kambizi, L., Afolayan, A.J., 2006. Indigenous knowledge and its impact on medicinal plant conservation in Gurube, Zimbabwe. *Indilinga Afr. J. Ind. Knowl. Syst.* 5 (1), 26–31.
- Keinan, A., Clark, A.G., 2012. Recent human population growth has resulted in an excess of rare genetic variants. *Science* 336 (6082), 740–743. <https://doi.org/10.1126/science.1217283>. (Retrieved: 12 March 2018).
- Kuipers, S.E., 1997. Trade in medicinal plants. In: Bodeker, G., Bhat, K.K.S., Burley, J., Vantomme, P. (Eds.), *Plants for Forest Conservation and Health Care. Food and Agricultural Organization of the United Nations (FAO)*, pp. 45–49. Available from: [www.fao.org/3/a-w7261e.pdf](http://www.fao.org/3/a-w7261e.pdf), Accessed date: 21 September 2015.
- Le Roux-Kemp, A., 2010. A legal perspective on African traditional medicine in South Africa. *Comp. Int. Law J. S. Afr.* 43 (3), 273–291.
- Lubbe, A., Verpoorte, R., 2011. Cultivation of medicinal and aromatic plants for specialty industrial materials. *Ind. Crops. Prod.* 34, 785–801.
- Mander, M., 1998. Marketing of Medicinal Plants in South Africa. A Case Study in Kwazulu-Natal. Report Presented to the Food and Health Organization of the United Nations, Rome. 158 pp. Available from: [www.fao.org/docrep/w91985e/w91985e00.htm](http://www.fao.org/docrep/w91985e/w91985e00.htm), Accessed date: 23 March 2017.
- Mander, M., Nthuli, L., Diederichs, N., Mavundla, K., 2007. Economics of the traditional medicine trade in South Africa. *S. Afr. Health Rev.* 2007, 189–196.
- Maroyi, A., 2013. Traditional use of medicinal plants in South-central Zimbabwe. *Rev. Perspect. J. Ethnobiol. Ethnomed.* 9 (31) (18 pp.).
- Maundu, P., Kariuki, P., Eyog-Matig, O., 2006. Threats to medicinal plant species - an African perspective. In: Miththapala, S. (Ed.), *Conserving medicinal Species. Securing a healthy Future. International Union for the Conservation of Nature (IUCN)*, pp. 47–58. Available from: <https://portals.iucn.org/library/efiles/edocs/2006-022.pdf>, Accessed date: 8 May 2015.
- McGaw, L., Jager, A., Grace, O., Fennel, C., van Staden, J., 2005. Medicinal plants. In: van Niekerk, A. (Ed.), *Ethics in Agriculture. An African Perspective*, (11 pp.) Available from Google scholar: <https://link.springer.com/book/10.1007%2F1-4020-2989-6> (Retrieved: 26 March 2018).
- Monakisi, C., 2007. Knowledge and Use of Traditional Medicinal Plants by the Setswana-speaking Community of Kimberley, Northern Cape of South Africa (M.Sc. Dissertation (Ecological Assessment)). University of Stellenbosch (162 pp.).
- Moolla, A., Viljoen, A.M., 2008. 'Buchu' – *Agathosma betulina* and *Agathosma crenulata* (Rutaceae): a review. *J. Ethnopharmacol.* 119, 413–419.
- Munro, A.M. and Holdgate, M.W. (Eds.). 1991. *Caring for the Earth. Guidelines for Sustainable Living*. Published in Partnership by the International Union for the Conservation of Nature (IUCN), United Nations Environmental Program (UNEP) and World Wide Fund for Nature (WWF), Gland. 236 pp. Available from: <https://portals.iucn.org/library/efiles/documents/CFE-003.pdf> (Accessed: 10 October 2015).
- Primack, R.B., 2012. *A Primer of Conservation Biology*, Fifth edition. Sunderland, Massachusetts. Sinauer (363 pp.).
- Prinsloo, G., Nogemane, N., 2018. The effect of water availability on chemical composition, secondary metabolites and biological activity in plants. *Phytochem. Rev.* 1–14.
- Rao, M.R., Palada, M.C., Becker, B.N., 2004. Medicinal plants in agroforestry systems. *Agrofor. Syst.* 61, 107–122.
- Rates, S.M.K., 2001. Plants as source of drugs. *Toxicol* 39, 603–613.
- Regassa, R., 2013. Assessment of indigenous knowledge of medicinal plant practice and mode of service delivery in Hawassa City, Southern Ethiopia. *J. Med. Plant. Res.* 7 (9), 517–535.
- Schippmann, U., Leaman, D.J., Cunningham, A.B., 2002a. Impact of cultivation and gathering of medicinal plants on biodiversity. Global trends and issues. In: *FAO. 2002. Biodiversity and Ecosystem Approach in Agriculture, Forestry and Fisheries. Satellite event on the occasion of the ninth regular session of the Commission on Genetic Resources for Food and Agriculture*. Rome, 12–13 October 2002. Inter-Departmental Working Group on Biological Diversity for Food and Agriculture, Rome (22 pp.).
- Schippmann, U., Leaman, D.J., Cunningham, A.B., 2002b. A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. In: Bogers, R.J., Craker, L.E., Lange, D. (Eds.), 2006. *Medicinal and Aromatic Plants*. Springer, Netherlands, pp. 75–95.
- Senanayake, S.G.J.N., 2015. Indigenous knowledge as key to sustainable development. *J. Agric. Sci.* 2 (1). <https://doi.org/10.4038/jas.v2i1.8117>. (9 pp.).
- Sibly, R.M., Hone, J., 2002. Population growth rate and its determinants. *Phil. Trans. R. Soc. Lond. B* 357, 1153–1170. <https://doi.org/10.1098/rstb.2002.1117>.
- South Africa, 1965. Medicines and Related Substances Control Act 101 of 1965 (73 pp.) Available from: [www.hpsca.co.za/Uploads/editor/UserFiles/downloads/legilations/acts/medicines\\_and\\_related\\_substances\\_control\\_act\\_107.pdf](http://www.hpsca.co.za/Uploads/editor/UserFiles/downloads/legilations/acts/medicines_and_related_substances_control_act_107.pdf), Accessed date: 12 February 2016.
- South Africa, 1996. Constitution of the Republic of South Africa Act 108 of 1996 (107 pp.) Available from: [www.gov.za/sites/www.gov.za/files/images/a108-96.pdf](http://www.gov.za/sites/www.gov.za/files/images/a108-96.pdf), Accessed date: 12 February 2016.
- South Africa, 1998. National Forests Act No. 84 of 1998 (41 pp.) Available from: <https://www.dwa.gov.za/Documents/Forestry/Tact84.pdf>, Accessed date: 12 February 2016.
- South Africa, 2003. National Environmental Management: Protected Areas Act 57 of 2003 (68 pp.) Available from: [www.saflii.org/za/legis/consol\\_act/nempaa2003467.pdf](http://www.saflii.org/za/legis/consol_act/nempaa2003467.pdf), Accessed date: 12 February 2016.
- South Africa, 2004. National Environmental Management: Biodiversity Act 10 of 2004 (43 pp.) Available from: [www.gov.za/sites/www.gov.za/files/38600\\_gen256\\_0.pdf](http://www.gov.za/sites/www.gov.za/files/38600_gen256_0.pdf), Accessed date: 12 February 2016.
- South Africa, 2005. Patent Amendment Act 20 of 2005 (3 pp.) Available from: [www.saflii.org/za/legis/num\\_act/paa2005189.pdf](http://www.saflii.org/za/legis/num_act/paa2005189.pdf), Accessed date: 20 May 2018.
- South Africa, 2007a. National Environmental Management: Biodiversity Act 10 of 2004: Notice on Bioprospecting, Access and Benefit-sharing. Notice 329 of 2007 (57 pp.) Available from: [www.saflii.org/za/legis/consol\\_reg/nemba10o2004rangnr447919.pdf](http://www.saflii.org/za/legis/consol_reg/nemba10o2004rangnr447919.pdf), Accessed date: 12 February 2016.
- South Africa, 2007b. Traditional Health Practitioners Act 22 of 2007 (25 pp.) Available from: [www.gov.za/sites/www.gov.za/files/a22\\_07.pdf](http://www.gov.za/sites/www.gov.za/files/a22_07.pdf), Accessed date: 12 February 2016.

- South Africa, 2008. Notice: Draft policy on African traditional medicine for South Africa. Notice 906 of 2008 (49 pp.) Available from. <https://www.gov.za/documents/policy-african-medicine-south-africa-draft>, Accessed date: 13 February 2018.
- South Africa, 2018. South African Population Growth. Available from. [countrymeters.info/en/south\\_africa#population\\_2018](http://countrymeters.info/en/south_africa#population_2018), Accessed date: 12 March 2018.
- Statistics South Africa, 1996. Available from. [www.statssa.gov.za](http://www.statssa.gov.za), Accessed date: 7 May 2015.
- Strydom, H.A., King, N.D., 2013. Fuggie and Rabie's Environmental Management, Second edition. Juta, Claremont (1142 pp.).
- Ticktin, T., 2004. The ecological implications of harvesting non-timber forest products. *J. Appl. Ecol.* 41, 11–21.
- Van Andel, T., Havinga, R., 2008. Sustainability aspects of commercial medicinal plant harvesting in Suriname. *For. Ecol. Man.* 256, 1450–1455.
- Van Wyk, B.-E., 2008. A review of ethnobotanical research in southern Africa. *S. Afr. J. Bot.* 68, 1–13.
- Van Wyk, B.-E., 2011. The potential of South African plants in the development of new medicinal products. *S. Afr. J. Bot.* 77, 812–829.
- Van Wyk, B.E., Gericke, N., 2007. People's Plants. A Guide to Useful Plants of Southern Africa. Briza, Pretoria, pp. 351.
- Van Wyk, B.-E., Oudshoorn, B., Gericke, N., 2013. Medicinal Plants of South Africa, Second edition. Briza, Pretoria (336 pp.).
- Venter, F., Venter, J., 2012. Making the Most of Indigenous Trees. Briza, Pretoria (320 pp.).
- Vermeulen, W.J., 2009. The Sustainable Harvesting of Non-timber Forest Products From Natural Forests in the Southern Cape, South Africa: Development of Harvest Systems and Management Prescriptions (PhD Thesis (Conservation Ecology)). Stellenbosch University (197 pp.).
- Wiersum, K.F., Dold, A.P., Husselman, M., Cocks, M., 2006. Conservation cultivation of medicinal plants as a tool for biodiversity and poverty alleviation in the Amatola Region, South Africa. In: Rogers, R.J., Craker, L.E., Lange, D. (Eds.), Medicinal and Aromatic Plants, pp. 43–57 Netherlands.
- Williams, V.L., Balkwill, K., Witkowski, E.T.F., 2000. Unravelling the market for medicinal plants and plant parts on the Witwatersrand, South Africa. *Econ. Bot.* 54 (3), 310–327.