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Review

Commercialization Potential of Six Selected Medicinal Plants Commonly Used for Childhood Diseases in South Africa: A Review

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Abstract: Globally, the potential of medicinal plants is increasingly being recognized due to their relative availability, particularly in rural areas. This review explored the ethnobotanical and economic values of six selected medicinal plants widely used to treat and manage childhood diseases in South Africa. *Acalypha glabrata*, *Aloe maculata*, *Datura stramonium*, *Gomphocarpus fruticosus*, *Rhoicissus tridentata* and *Vachellia karroo* were selected based on their high relative frequency of citations for treating a wide range of diseases. Information was obtained from various scientific databases and ethnobotanical books. In addition to being popular for treating childhood diseases, the selected medicinal plants possess diverse applications in traditional medicine for other age groups, highlighting their general therapeutic values. This translates to extensive harvesting, trading and consumption of these plants in order to meet demands on local levels. Currently, empirical data on the economic value of the selected plants remain poorly reported. Even though South Africa has many laws to conserve and promote indigenous knowledge and medicinal plants, their commercialization remains low. Particularly the cultivation of the selected plants needs to be promoted under a participatory management action plan to stimulate the economy of the disadvantaged. A collaborative research framework for the inclusive transformation of indigenous medicinal plants is recommended to reveal their concealed beneficial properties.

Keywords: child health; commercialization potential; conservation status; livelihood; policy; rural economy

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1. Introduction

The use of medicinal plants provides a valuable contribution to alternative primary healthcare [1,2]. An estimated 80% of the global population uses traditional medicine to treat and manage various diseases [3]. The use of medicinal plants has increased in the 21st century, particularly with the emergence of severe diseases such as diabetes, cancer and skin-related conditions [4]. Many publications detail the use of traditional medicine among various ethnic communities, particularly for human and animal-related conditions [5–7]. The number of medicinal plant species is estimated to be between 35,000 and 50,000, with approximately 4000–6000 species entering the global medicinal plant market annually, which is worth approximately US $83 billion [8].

In developing countries, the widespread use of medicinal plants has resulted in traditional healthcare becoming a profitable business for multinational corporations, who

have identified the active ingredients and found a lucrative business in medicinal plants [9]. Traditional medicine is commercialized and exported to different countries for product development. This implies that medicinal plants contribute both directly or indirectly to the economy of rural households through providing welfare and economic status [10,11]. Some traditional health practitioners and knowledge-holders have chosen to market their knowledge outside of traditional settings. This contributes to the advancement of pharmaceutical treatments by providing information about the active ingredients derived from plants.

In many instances, there has been inadequate documentation of indigenous knowledge about medicinal plants and their utilization. Medicinal plants have been one of the main ingredients in traditional medical systems, being in high demand in both rural and urban livelihoods and an important source of human survival and well-being [12]. Medicinal plants used to treat and manage childhood diseases in particular are recognised in rural areas due to their ability to provide welfare and wellbeing to traditional health practitioners, particularly those who practice and believe in the use of medicinal remedies [3].

In South Africa, approximately 27 million inhabitants rely on traditional medicine, with an estimated 20,000 tons from 771 medicinal plants being harvested from the wild population [13]. The increasing South African population and urban migration has resulted in the establishment of competitive medicinal plant markets, especially in cities [14]. The traditional medicine industry is unregulated, with an estimated contribution of ZAR 2.9 billion (USD 192,948,107) to the economy per annum [13]. In many rural areas, people die of preventable or curable diseases due to a lack of adequate healthcare facilities, road infrastructure and telecommunication network coverage to reach emergency facilities [15]. As a result, many rural communities resort to the use of traditional medicine as an alternative medicine, a trend that has been observed in urban areas where there are many '*Muthi*' markets (traditional markets).

Although many of the medical floras consumed by the South African public remain poorly explored by scientists [16], the use of medicinal plants has remained popular for historical and cultural reasons [5,17–20]. Most studies have overlooked the medicinal plants used for treating and managing childhood diseases, as well as their economic benefits to the livelihoods of individuals who cultivate or harvest them. While there is a financial benefit from the sale of medicinal plants in the informal sector, it remains largely undocumented and forms part of the 'hidden' economy [21].

There are limited studies on the economic importance of high-value medicinal plants used for child-related diseases [22], and this is an indication of the extent of neglect in monitoring and documenting such medicinal plants [22]. A large number of medicinal plants used to treat and manage childhood diseases are regularly sold as crude, unprocessed drugs in local '*Muthi*' markets in several parts of South Africa [23]. Traders of medicinal plants experience numerous challenges including the absence of formal arrangements provided by city officials with good infrastructure and resources.

In South Africa, the need to reduce infant and child morbidity and mortality is one of the greatest challenges in rural areas [24]. In South Africa, the child mortality rate varies across communities, with the highest (56/1000) being for children under the age of five [15], this being above the WHO's desired level of reducing child mortality rate. A previous study indicated inequalities in the provision of healthcare services between and within South African provinces, with urban areas being better resources than rural ones, which is one of the major causes of poor health and premature death among children [25]. The cultivation and trading of medicinal plants that are used to treat childhood diseases remains an alternative measure to reduce the child mortality rate and increase economic activities. As indicated in several studies [26,27], the demand for medicinal plants creates possibilities for their local cultivation. Such endeavours could help raise employment in the rural economy, boost commerce and possibly contribute to the health of millions. In this regard, this review explored the economic potential of six medicinal plants that are used for childhood diseases in South Africa. We previously generated an inventory of 194 medicinal plants used for childhood disease in South Africa [22].

2. Methods

For the selection of articles for this review, we followed a systematic approach as described by Shamseer et al. [28], called the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). To find relevant articles, we used keywords and terminologies such as economic and industrial relevance, high-value medicinal plants, ethnomedicine, folk-paediatric, paediatric, childhood diseases, indigenous medicine, and phytomedicine. The bibliographies from the retrieved papers were also checked and saved using Endnote reference manager. Plants were selected in this research based on their traditional use in the treatment of multiple childhood diseases. The plants were selected for their health and economic potential with respect to childhood diseases. The six medicinal plants were selected based on their high frequency of citations in the literature and high number of uses for managing three to six childhood diseases. Search engines such as Web of Science, Science Direct, Google Scholar, PubMed, Scopus and JSTOR were accessed for relevant studies. Screening of the published literature was guided by the scope predefined for the current study. Aside from the peer-reviewed journals, theses and dissertations, books were obtained from the libraries of North-West University (NWU) and the University of Mpumalanga (UMP), South Africa. A total of 1635 articles were obtained based on the keywords used for the search. Additional data were collected from 20 sources located at NWU and UMP libraries (Figure 1). Following the removal of duplicates, the remaining 1303 were screened with respect to the eligibility criteria and articles related to ethnoveterinary, wild food and those more than 15 years old were excluded from the selection because they did not meet the criteria and the scope of the study. We accessed the full texts of the resultant 369 publications. The research papers (systematic or literature) exclusively dealing with current childhood diseases were retained. Thereafter, 266 articles were removed due to the lack of sufficient information regarding the scope of this review, while 104 articles were included to complete this study.

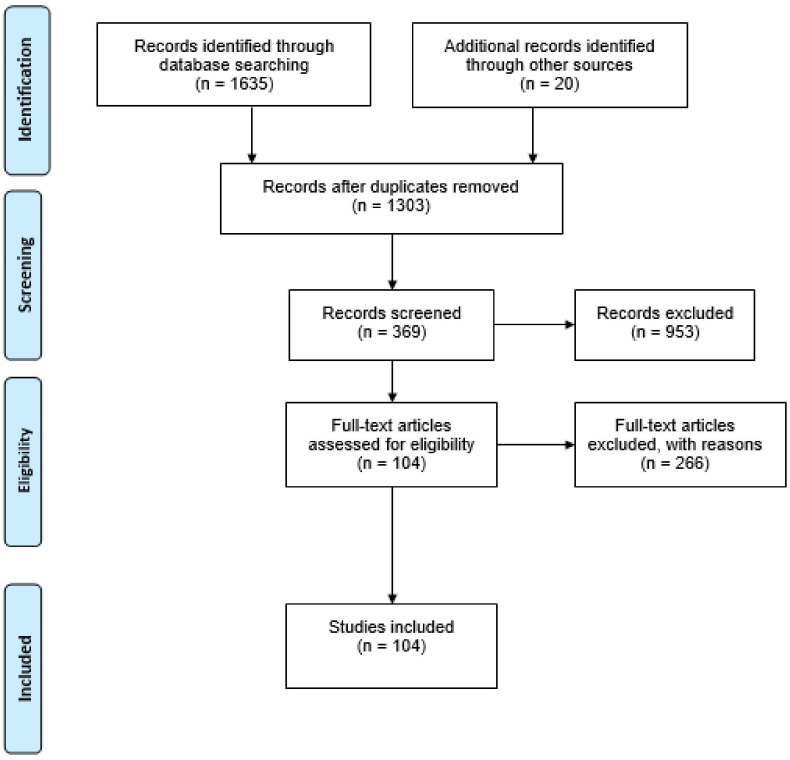

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for the exclusion and inclusion of articles for the current review.

3. Distribution and Occurrence of the Selected Medicinal Plants

The six selected medicinal plants identified are (a) *Acalypha glabrata*, (b) *Aloe maculata*, (c) *Datura stramonium*, (d) *Gomphocarpus fruticosus*, (e) *Rhoicissus tridentata* and (f) *Vachellia karroo*, which have diverse distributions globally (Figure 2). For example, the members of the genus *Acalypha* have succulent leaves with sappy stem and are regarded as the fourth largest genus in the Euphorbiaceae [29]. There are approximately 65 *Acalypha* species in tropical Africa and 35 on Indian Ocean islands (Figure 2a). In Asia and Africa, the majority of the species in this family are utilized as medicinal herbs [29], and *A. glabrata* is distributed in four provinces of South Africa [30].

The *Aloe* genus is mainly indigenous to Africa but is widely distributed globally [31,32], being widely distributed in Africa, India and other arid areas (Figure 2b). As one of the most common *Aloe* species, *A. maculata* is well-defined by a suite of characters that includes maculate (spotted) leaves, flat-topped inflorescences and uniformly coloured flowers [33]. Globally, about 548 *Aloe* species are known to exist, with South Africa contributing 140 (26%) species [30]. In South Africa, *A. maculata* occurs in the Western Cape, KwaZulu-Natal, Mpumalanga and Limpopo provinces [30], and is known by different local names and diverse uses [34].

Datura stramonium is a wild-growing plant in the family Solanaceae (Figure 2c). It is widely distributed and easily accessible, particularly in open locations such as grassland, roadsides, waste places, scrub vegetation and open forest [35]. The plant species has wide leaves and large fruit, with few but stout spines [35]. It is indigenous to the Americas and has been introduced into many tropical and subtropical regions [36], having been cultivated in Europe and South America [36,37]. It is a naturalized weed in many developing countries but is probably under-reported.

Gomphocarpus fruticosus (family: Apocynaceae) is a herbaceous, perennial, spindly shrub, often with watery or milky sap with milkweed that is fibrous [38,39]. The plant is a small shrub, approximately 2 m tall, with thin stems that are adorned with large round-shaped seed pods, oppositely connected leaves and yellowish-green blooms in dangling clusters. It is native to South and Tropical Africa (Figure 2d), but is also found in North Africa and the Arabian Peninsula as an exotic plant [40]. Although it has been naturalized and is widely distributed in South Africa, it is an imported weed native to several tropical African countries, such as Botswana, Eswatini, Kenya, Mozambique and Zimbabwe [34]. In South Africa, *G. fruticosus* is found across several provinces, including Mpumalanga, the North West, KwaZulu-Natal, Eastern Cape, Western Cape and Limpopo [41].

Rhoicissus tridentata is a deciduous shrubby creeper of the family Vitaceae, commonly known as wild grape, which has 700 to 800 species spread over 13 to 14 genera [30]. The plant has greenish-yellow flowers that bloom in late summer in tight clusters on a thickly hairy inflorescence, and when young, the trifoliate leaves are bright green, but as they develop, they become grey [42]. Studies have shown that the majority of these genera are thought to be mostly found in tropical and subtropical areas [43] (Figure 2e), ranging from Africa to Asia and the Pacific Islands [43].

Vachellia karroo is distinctly based on several morphological, anatomical and biochemical attributes, and belongs to the *Acacia* genus of the family Leguminosae [44]. *V. karroo* (previously *Acacia karroo*) is indigenous to southern Africa and known as "sweet thorn" [45,46], being found in different habitats from low to highveld areas. The plant has been used as traditional medicine by many local inhabitants of southern Africa and is a common woody species in South Africa. Its distribution ranged from the Western Cape in South Africa to neighbouring countries such as Zambia and Angola (Figure 2f). In tropical Africa, it is replaced by *Acacia seyal*, which has probably been renamed.

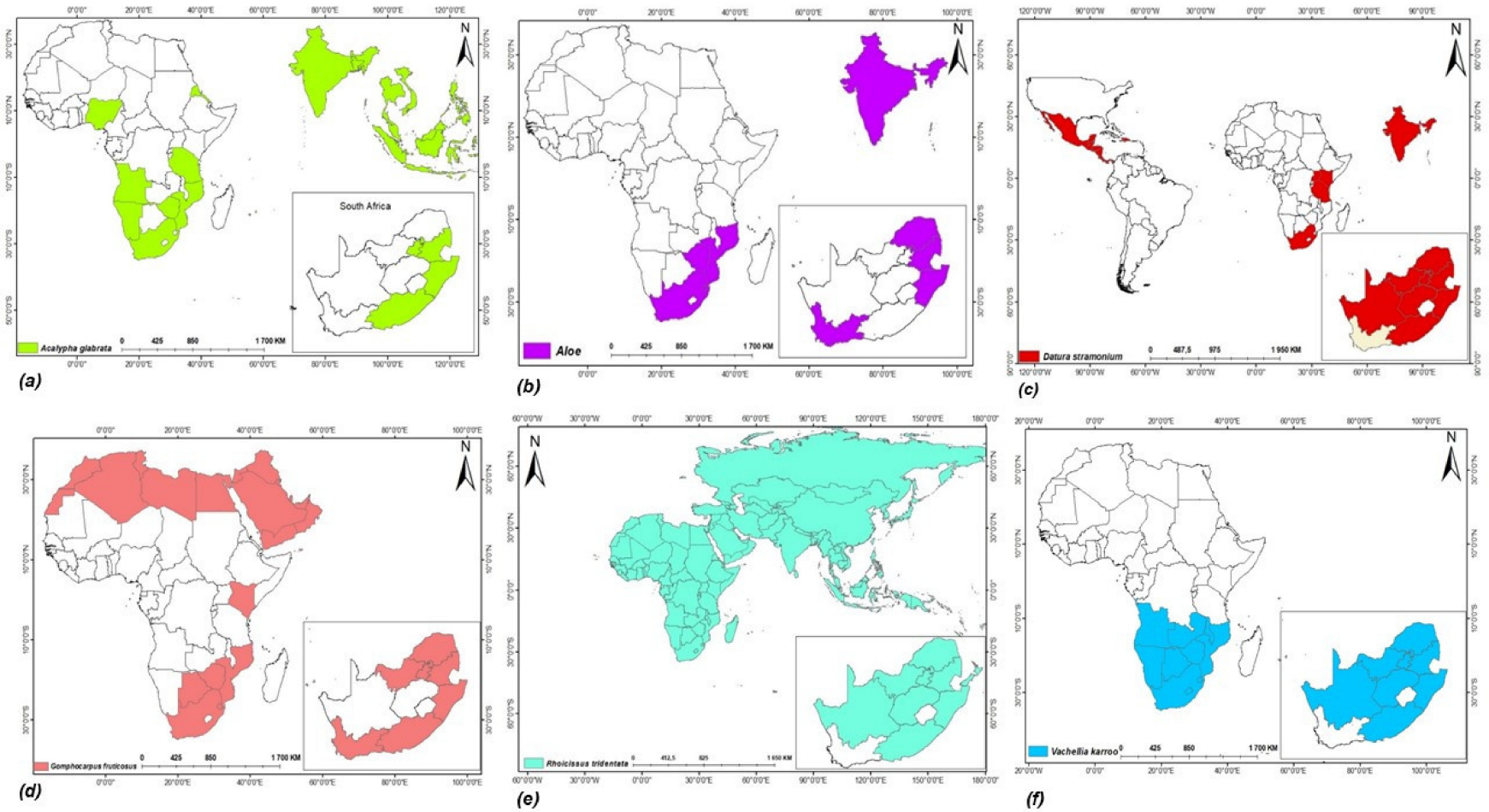

Figure 2. Distribution map of the selected medicinal plants: (**a**) *Acalypha glabrata*, (**b**) *Aloe maculata*, (**c**) *Datura stramonium*, (**d**) *Gomphocarpus fruticosus*, (**e**) *Rhoicissus tridentata* and (**f**) *Vachellia karroo*.

4. Ethnobotanical Uses of the Six Medicinal Plants

The six medicinal plants described in this review have a variety of medical values and are widely used to treat childhood diseases (Figure 3). However, they are characterized by limited exploration in terms of their potential, especially from health and economic perspectives. For instance, *A. glabrata* is known to treat skin-related ailments among children [40,47,48]. As indicated by Van Wyk et al [30], the leaves and bark of the *Acalypha* genus are traditionally used to treat and manage diverse ailments including skin rash [30]. The majority of the *Acalypha* genus species are utilized as medicinal herbs in Asia and Africa [29,30,48]. In South Africa, *Acalypha glabrata* is relatively scarce and traditional health practitioners often find it difficult to cultivate in their home gardens due to limited seed supply [48].

Figure 3. Six South African plants widely used for managing childhood diseases (**a**) *Acalypha glabrata* (**b**) *Aloe maculata*, (**c**) *Datura stramonium*, (**d**) *Gomphocarpus fruticosus*, (**e**) *Rhoicissus tridentata*, (**f**) *Vachellia karroo*.

Aloe maculata is one of 548 accepted *Aloe* species, of which at least one-third are documented as having some indigenous utilitarian value globally [31]. Over 350 multidisciplinary publications surveyed the uses and useful properties of *Aloe* spp [48,49]. Unsurprisingly, *A. maculata* is rich medicinal component and has diverse uses in folk medicine to treat various childhood diseases. *Aloe* flowers are traditionally infused and used as a laxative agent and for pain relief [50], while some species, such as *A. maculata,* are used in ethnoveterinary medicine [50]. Despite the large number of uses, only a few have been commercially exploited, such as 'Forever Living Products,' which are sold globally, with many South Africans being involved in the selling scheme. The commercial trade in *Aloe*-derived natural products is based mainly on two materials (excaudate and the gel) that are obtained from the leaves of certain *Aloe* species. These components are used as laxatives, applied topically for skin ailments or taken internally for digestive complaints and general well-being [50].

Datura stramonium is a commonly known traditional herb, with both poisonous and medicinal properties, which has had great pharmacological potential and a considerable

utility in traditional medicine [36,50]. It contains highly toxic tropane alkaloids, including the pharmacologically active compounds atropine and scopolamine [50], the former being a highly toxic substance with a lethal dose in humans in the range of 100 mg [47]. Several studies revealed that the leaves of this plant are used for childhood ailments [5,20,51] and for curing various diseases among adults in Ayurvedic medicine [50]. Furthermore, *D. stramonium* leaves are used to relieve headaches, and the vapours of leaf infusions are used to alleviate the discomfort of rheumatism and gout, while asthma and bronchitis are eased by inhaling the smoke from a burning leaf [36]. In Europe, the plant is used to cure haemorrhoids by steaming the leaf over boiling water, and its juice is applied to the scalp to treat dandruff and hair loss, as well as wounds and sores [37].

The whole plant or leaves of *G. fruticosus* are used to treat various diseases including coughs, diabetes, tumours, skin diseases [4,5,38,48] and impotence [50,52] in humans as well as retained placenta in cattle [53]. It is regarded as a species of ethnobotanical interest in Kenya and Lesotho [54,55]. In tropical Africa, it is used to treat malaria, diabetes, asthma, bronchitis and cardiac palpitations. Furthermore, it is used for managing tumours, skin diseases, scabies and itching in the Arabian Peninsula [40]. In Egypt and South Africa, *G. fruticosus* is regarded as ethnoveterinary medicine [40,53]. Despite being known for its ethnobotanical uses and medicinal properties, the economic value of *G. fruticosus* remains unexplored and unknown (Table 1).

In South Africa, *R. tridentata* has been used to treat various childhood diseases, such as pulsating anterior fontanelle, stomach-ache and to stop vomiting [4,20,56]. In addition, it is a popular remedy for treating and managing diseases, such as broken bones, cuts, epilepsy, menorrhagia, sprained ankles and gastrointestinal disorders [4,30,57]. Evidence of its use as ethnoveterinary medicine has been indicated [58,59], and is listed as one of the 'rare' species (http://redlist.sanbi.org/species; accessed on 15 August 2021). There have been limited economic value chain studies of *R. tridentata* despite it being heavily traded and unsustainably harvested [26].

In humans, *V. karroo* has been used for many conditions such as gastrointestinal disorders, candidiasis and skin infections [4,60–64]. In addition, it is a well-known ethnoveterinary medicine [55,61,65]. Despite being highly utilized, there is limited knowledge regarding its commercial and economic impact, and product development (Table 1). The leaves of *V. karroo* are known to be a meal supplementation for natural pasture, with a fresher appearance and higher protein content. It is economically beneficial for beef farmers as it improves the meat nutritive value and freshness, and therefore increases consumer acceptance of the meat produced from these livestock [66].

Table 1. Most frequently cited plants used for treating and managing childhood diseases in South Africa.

Scientific Name and Family	Childhood Diseases/Conditions	Plant Parts and Preparation	* Conservation Status in South Africa	Reference	Region(s) of Availability	Signature Phytochemicals
Gomphocarpus fruticosus (L.) W.T. AitonApocynaceae	Convulsions, stomach ailments, chest ailments and milk latex used for the treatment of warts	Whole plant, leaves Infusion/poultice	LC	[4,5,48]	North Africa and the Arabian Peninsula [40]; Southern Africa and East Africa [34,41]	Glycosides [40]
Acalypha glabrata Thunb. Euphorbiaceae	Skin-related problems (e.g., skin rashes)	Stem, bark A sufficient amount of fresh stem is cut open and gently heated over an open fire before being applied to the skin.	LC	[67,68]	Indian Ocean islands, Asia and Africa [29,69]	-
Vachellia karroo Hayne Banfi and Galosso Syn: *Acacia karroo* var. transvaalensis (Burtt Davy) Burtt Davy Leguminosae/Fabaceae	Diarrhoea, dysentery, colic and convulsions	Whole plant Infusion and decoction	LC	[4,60,70]	Southern Africa [45,46]	Tannis and flavonoids [30]
Datura stramonium L. Solanaceae	Ailments such as mumps, earache (otitis)	Leaves, Maceration	IA	[5,20,51]	Europe and South America [36,37]	Tropane alkaloids [47,71]
Rhoicissus tridentata (L.f.) Wild and Drummond. Vitaceae	Pulsating anterior fontanelle, stomach-ache and stop vomiting	Roots, leaves Infusion/Maceration	R	[4,20,56,63]	Africa to Asia and the Pacific Islands [43]	Anthocyanidin [30]
Aloe maculata All. Xanthorrhoeaceae	Feverish colds, induce vomiting and weaning	Flower, Infusion	LC	[4,20,38]	Africa, India and other arid areas [31,32]	Acetylated mannans, polymannans, anthroquinones, anthraquinone glycosides, anthrones, lectins [72,73]

* Conservation status: LC = Least concern; IA = Invasive alien species and R = Rare. The botanical names were verified using the world flora online (http://www.worldfloraonline.org/) and conservation status were verified using the South African Red data list (http://redlist.sanbi.org/species, accessed on 15 August 2021).

5. Benefits and Economic Prospects of Selected Medicinal Plants

The African Union (AU) head of states has emphasized that African Traditional Medicine (ATM) is important to local livelihoods, as the mainstream medicines and other medical supplies can be costly, with many developing countries being unable to afford to purchase orthodox medicine to meet people's health needs [74]. Plants such as *A. glabrata*, *A. maculata*, *D. stramonium*, *G. fruticosus*, *R. tridentata* and *V. karoo* are important resources for livelihoods in local communities (Table 1). In particular, *Aloe* species have gained prominence as key natural resources that may contribute to the livelihoods of the poor. According to Idamokoro et al. [75], *V. karroo* together with other *Acacia* species are valuable feed resources that can be utilised by livestock in semi-arid areas. Furthermore, the foliage is a cheap and widespread non-conventional feed resource that can be utilised by low-input communal farmers to boost goat production in semi-arid areas of southern Africa. Feeding goats with *V. karroo* leaf meal can help to improve animal performance, including reducing the worm burden and increasing the growth rate, meat quality and colour. In South Africa, several indirect policy initiatives support the marketing of ATM by attempting to improve the standard of traditional medicine practice. Despite the policies and the legislation developed at the national government level, the promotion and protection of medicinal plants, and construction and regulation of a market for street traders remains low at grassroot levels [13]. Notwithstanding the different policies and initiatives of protecting and promoting indigenous knowledge, there is limited information specifically supporting the marketing of traditional medicinal plants used for childhood diseases at a national and grassroot levels.

Even though the selected plants (*A. glabrata*, *A. maculata*, *D. stramonium*, *G. fruticosus*, *R. tridentata* and *V. karoo*, Figure 3) play important roles in the South African traditional medicine, their potential economic benefit is often underestimated or unknown. Furthermore, medicinal plants may be important tools for addressing poverty in marginalized communities, by contributing to livelihoods, including food security, income, health and sustainable human development [1]. Specifically, *V. karroo*, *R. tridentate* and *G. fruticosus* serve as useful sources for different purposes and could be important income generators, especially for poor people in rural areas [76–78].

6. Challenges to Unlocking Potential of Selected Medicinal Plants

There are a number of challenges regarding unlocking the potential of these selected plants. One of the critical aspects is policy integration. Others include agro-processing and commercialization.

6.1. Policy Integration and Medicinal Plants

A number of acts have been passed in South African to regulate the use and conservation of medicinal plants. The National Environmental Management: Biodiversity Act 10 of 2004, which complies with the Convention on Biological Diversity [79], has spearheaded the Bioprospecting, Access and Benefit-Sharing Notice 329, the National Biodiversity Strategy and Action Plan, and the National Biodiversity Framework to foresee the sustainable use and conservation of biological resources [80]. The National Environmental Management: Protected Areas Act 57 of 2003 provides and facilitates access to natural resources where it has been prohibited before, but with a focus on the principle of sustainability [81]. In addition, the National Forests Act 84 of 1998 protects South African forests and trees through a licensing system.

In 2005, the government of South Africa promulgated the 2004 Traditional Health Practitioners (THP) Act, which recognized the practice of traditional medicine and established an Interim Traditional Health Practitioners Council [82]. According to the policy on African Traditional Medicine Notice 906 of 2008 [83], the South African Department of Health that ratified the AU plan adopted the 2007 Head of State Summit in Lusaka on the Plan of Action of the decade, that African traditional medicine should be institutionalized in the

public health systems. The South African Constitution (1996) also allows conventional and indigenous or traditional medicine practices to coexist within the public health system.

In South Africa, the Department of Science and Technology (now referred to as the Department of Science and Innovation) was mandated to harmonize the policy and its implementation to ensure lucidity on issues related to the indigenous knowledge system (IKS) and the "*sui generis*" laws on the intellectual property housed by the Department of Trade and Industry (to facilitate registration of indigenous knowledge holders). In 2004, the policy stance saw the establishment of legislative bodies that include the National Office of IKS (NIKSO), which was tasked with recognizing and promoting indigenous knowledge, known as IKS Act 6 of 2019 [84]. South Africa has several laws, although some lack an integrated legislative framework or an appropriate regulatory body for traditional medicine. There are currently difficulties with the registration of African Traditional Medicine (ATM) and complementary medicines. South Africa still faces many constraints with the indigenous medicinal plant market, such as relevant policy, limited government recognition of the associated opportunities and poor implementation of the existing frameworks.

Most commercial acts in South Africa are silent regarding indigenous and traditional plants, despite acknowledging the use of traditional medicine and the practical constraints associated with low-income plants. The agricultural policy goals are represented in the National Development Plan (NDP) of 2030, which promotes crop commercialization under the prevailing food system [85]. However, it remains mainly silent about the cultivation of medicinal plants. Similarly, an observation was made in the National Food and Nutrition Security Policy that speaks about efficient agricultural output but remains silent on medicinal plants used for childhood or any other diseases [86–88].

Currently, the IKS Act 6 of 2019 reflects a developmental agenda and aims to develop, promote and preserve the local knowledge of different communities in South Africa. The Act aims at reducing the limitations facing local communities regarding their knowledge systems while creating opportunities for the inclusion of indigenous knowledge into local livelihoods. This includes the harmonization of the laws related to the NEMBA Act 10 of 2004, Access and Benefit-sharing Notice 329 of 2007, National Forests Act 84 of 1998, Land act, African Traditional Medicine Notice 906 of 2008 and the THP Act of 2004. However, there are inconsistencies in the policies related to indigenous knowledge and natural recourses as the divergent views held by policy makers and lawmakers on how to address problems of equity, nutrition security and poverty reduction. Medicinal plants have an explorable potential to grow the local economy. However, they are often excluded from the policy and strategic documents, except for the well-known ones.

The recognition of indigenous plants for medicinal purposes could be used to leverage their incorporation into policy documents and implementation processes and to improve local livelihoods [89]. Many South Africans living in rural areas who rely on ATM for healthcare are often caught in a vicious circle of malnutrition, poor access to healthcare and low standards of living, which are exacerbated by poor socio-economic conditions [90]. The effects of low income and poor wellbeing are exacerbated by people's inherent vulnerability to socio-economic factors [91]. Given the evidence presented above, it is pertinent to explore ways and paradigm shift to support vulnerable South African populations, and improve their healthcare status, socio-economics status and well-being through prioritizing indigenous knowledge of medicinal plants.

To create an enabling environment for the use of medicinal plants a different approach needs to occur at the local level, a multi-disciplinary research approach involving medicinal plants, agro-processing and other socio-scientific parameters is required to inform policymakers of the sustainable indigenous plant-based healthcare system that needs to be formalized in South Africa. This will require strengthening the capacity of South Africa to include both complementary and indigenous healthcare systems, in compliance with government commitments to adopt the proposed collaborative framework (Figure 4).

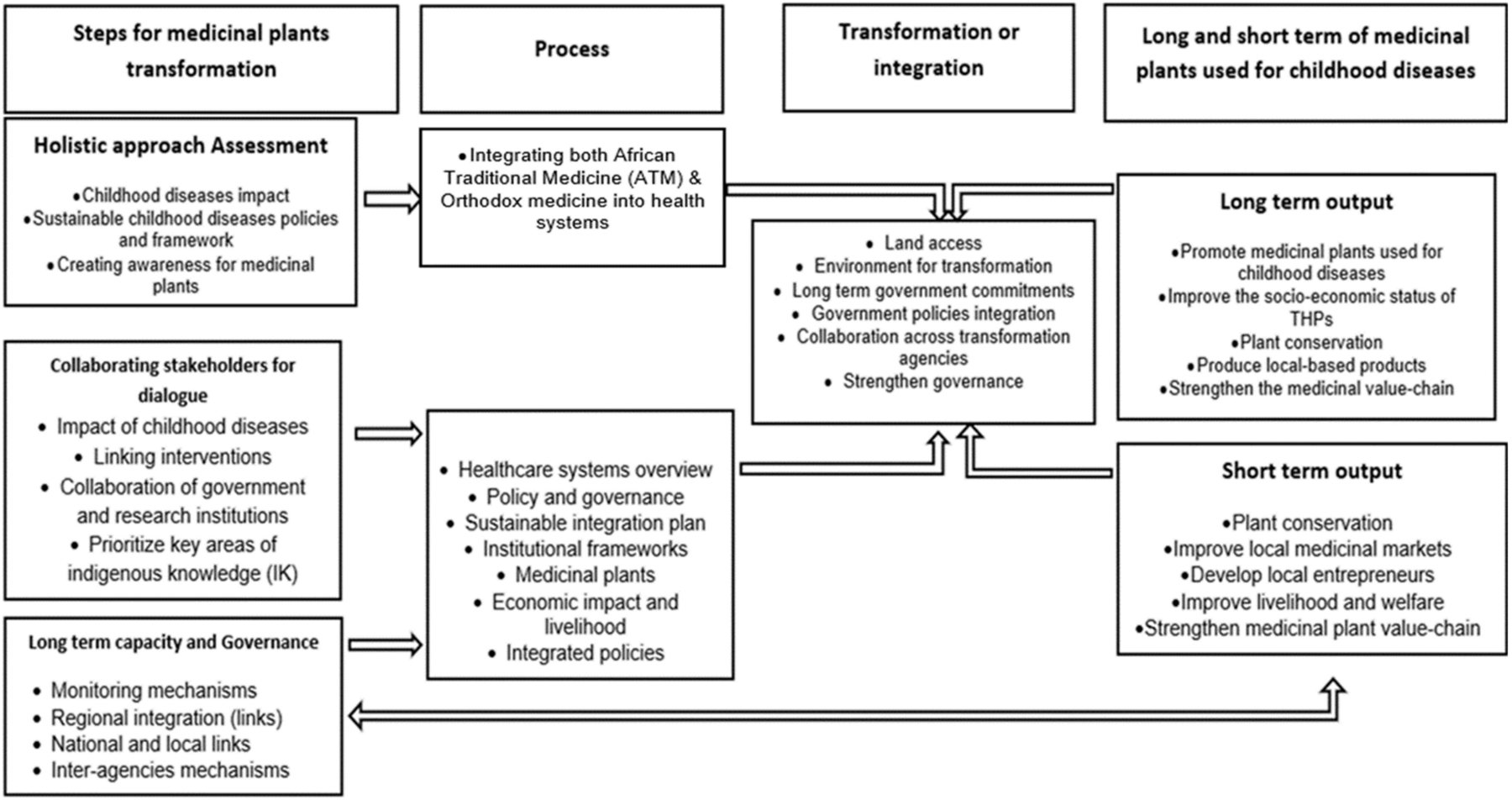

Figure 4. A proposed collaborative framework for medicinal plants used for managing childhood diseases.

Traditional medicine is the total sum of all knowledge, skills and practices based on the beliefs and experiences of the various indigenous cultures [92]. Developing the medicinal plant market could be an important determinant of short- and long-term economic growth in rural areas [8,93]. Creating an awareness of the use of medicinal plants and assessing the impact of different policies on knowledge accumulation is an important strategy for the growth of the local economy. Commercialization policy remains a controversial aspect to both indigenous knowledge and science that needs to be balanced. Policies are needed that (i) allow stronger incentives for economic agents to engage in knowledge-creation activities and (ii) encourage people and organizations to invest in research and development of new medicinal plant products. Research and development is essential for organizational innovation and competition to improve people's quality of life through their participation in small- and medium-sized enterprises, these being the backbone of the local economic sector [94,95].

Integrating both ATM and orthodox medicine into the healthcare systems should be prioritized by the government commitments and policies at all levels. This will be accomplished by engaging stakeholders for discourse, increasing the number of local enterprises to develop indigenous products and strengthening local pharmaceutical markets. Furthermore, to boost the medicinal plant value chain, monitoring methods, ranging from national to regional to local and inter-agency systems should be created to improve the local livelihood of local communities.

6.2. Agro-Processing of Medicinal Plants

In developed countries, agro-processing is regarded as one of the "sunrise sectors" for an economy, with significant development opportunities and socio-economic impacts for jobs and income generation [96]. To avoid spoilage or waste of produce, agro-industry converts agricultural materials into semi-finished goods [97]. Furthermore, agro-processing has a significant potential to prompt development in other sectors of the economy through the multiplier effect (Figure 4). It can create employment away from farms and processing units in sectors, such as transportation, distribution and retailing. Many developing countries continue to depend on importing orthodox medicines while having the potential for substantial production of local indigenous medicinal plants (Table 1). However, the economic value and agro-processing of medicinal plants used for childhood diseases remains poorly studied.

6.3. Commercialization of Medicinal Plants

The demand for plant-based products is increasing at the rate of 15 to 25% annually. Based on the estimate by the World Health Organization (WHO) [3], the demand for medicinal plants is likely to increase by more than USD 5 trillion by 2050 [98]. Despite an increase in the international trade of medicinal plants, their commercial benefits for childhood diseases remain speculative. South Africa exported 6497 tons of medicinal plant materials in 2015, compared to 1143 tons in 2014 [81]. According to the South African government, medicinal plants contributed approximately ZAR 82 million (USD 5,494,763) to the Gross Domestic Product (GDP) in 2014. Although this is currently a small industry, it has potential of making a greater contribution to the GDP, potentially increasing from ZAR 115 million (USD 7,000,874) to ZAR 150 million (USD 10,044,300). Despite the economic impact, the extent of medicinal plants' contribution to the social fabric remains largely unknown in many rural areas. Medicinal plants including *V. karroo* make a range of contributions to the livelihood and profitability of residents in rural areas. Despite the lack of documentation on agro-processing and commercial development, many medicinal plants continue to be traded for rural economic development [99].

Medicinal plants are sold in both urban and rural markets, and provide a substantial income to the small-scale vendors and traditional health practitioners for livelihood substance [100]. However, the adoption of large-scale cultivation of the above-mentioned medicinal plants remains low and unknown due to limited and undocumented economic

returns on investments. These results are in line with a previous study, which estimated that only 10% of the South African plants have been completely commercialized, with their scientific evaluation often being unavailable [9]. This is attributed to a lack of organization and networking by the often rural collectors of medicinal plants from the wild and increased transactional costs, a constraint exacerbated by increasingly stringent health and safety requirements in the developed markets. Even basic pricing information on the indigenous plants we studied is scant. For example, a 2005 study surveyed prices of *R. tridentata* at ZAR 0.03/kg (USD 0.002/kg) of dry weight for the tuber and *A. glabrata* at ZAR 0.50/kg (USD 0.031/kg) of dry weight for the bark [78].

7. Prospects of Unlocking the Potential of Selected Medicinal Plants

7.1. Promoting Collaborative Research and Sustainability

The government and private stakeholders have to identify and recognize the importance of *A. glabrata*, *A. maculata*, *D. stramonium*, *G. fruticosus*, *R. tridentata* and *V. karroo* for childhood diseases in rural areas to conserve and protect the associated traditional knowledge for future generations [22]. Therefore, it is necessary to encourage the farmers, pharmaceuticals companies, institutions of higher learning (universities) and other stakeholders along the value chain in managing soil health, producing quality seeds and good marketing to undergo training and provide a policy framework that is beneficial to rural communities [101]. Developing a comprehensive and workable monitoring and evaluation framework for any kind of social system will be beneficial towards building linkages, interactions and resource flows between entities, responding and adapting to new demands and priorities in their environment [102]. Some strategies are not necessarily formal plans but rather abstract visions.

7.2. Technology Application and Product Development

Plant-derived pharmaceuticals are the next major commercial development in biotechnology because of the advantages that they offer in terms of production scale and value chain in both developing and developed countries. The provision of modern technological infrastructural facilities including state-of-the-art storage facilities and processing machinery is required in local communities where the plants originally occur and are harvested [9]. This will provide efficient agro-processing aligned with the drive for a modernized product and the preparation of monographs within the pharmacopeia production systems in Africa [9]. In addition, it will enhance the income and livelihood of households in rural communities and the durability of highly utilized plants such as *A. maculata* and *V. karroo*.

7.3. Promoting a Useful Value Chain

In South Africa, the medicinal plant trade proceeds with little government intervention or documentation. Both traders and traditional health practitioners benefit from this informal market. However, this market works in a grey area and policy makers are often unaware of the importance of medicinal plant value chains, which are essential towards commercialization. For instance, the *Aloe vera* value chain is distinguished from the informal nature of its upstream base, when compared to other *Aloe* species. The consistency of raw material supply as a result of a developing market is critical in marketing the above-mentioned plants. Medicinal plants relative to their bio products have different value chains. To promote a successful value chain for the selected medicinal plants, the policymakers and local communities should consider several aspects such as awareness of environmental factors, increased research and opportunities related to promoting active collaboration with local communities, and mainstreaming gender-sensitive approaches [103]. Furthermore, different organizations and policy makers should be consulted and participate in the open process to promote the effectiveness and relevance of medicinal plants (Figure 5).

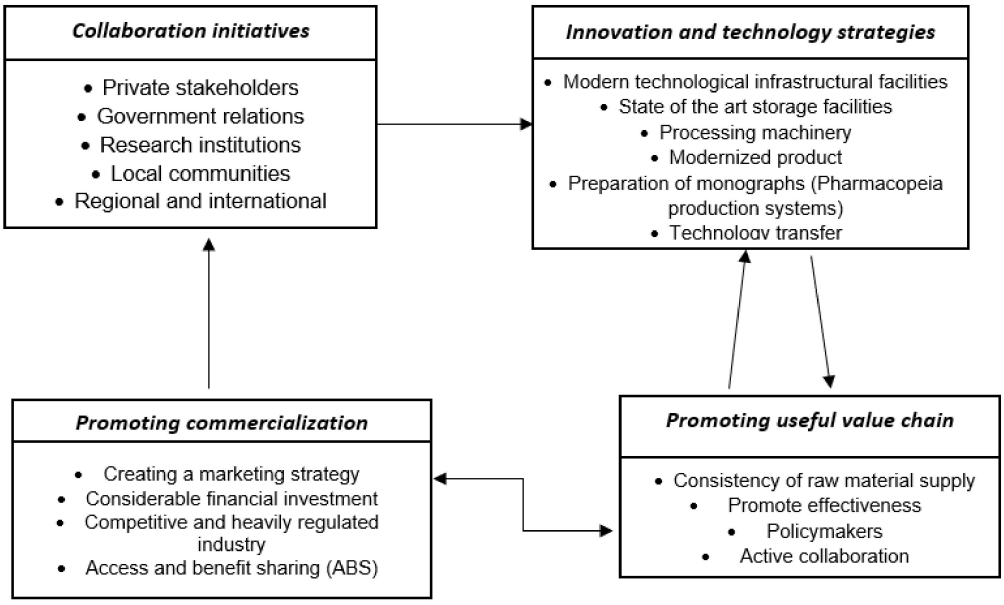

Figure 5. Prospects for unlocking the potentials of the selected medicinal plants widely used for managing childhood diseases in South Africa.

7.4. Potential of the Selected Plants for Commercialization

The need to enhance medicinal plant production and commercialization cannot be overemphasized. These medicines provide healthcare to the communities and can be further explored to generate income for the producers. Plants such as *A. maculata*, *D. stramonium* and *V. karroo* are utilised for primary health for humans and serve as ethnoveterinary medicine. Despite the increased global commerce in *Aloe* species, the benefits to developing countries, particularly growers and producers, remains limited [104]. As a result, in a competitive and heavily regulated industry that requires both specialist knowledge and a significant financial investment to become certified, there is a need to develop marketing, ecological and social strategies that mediate access to benefits from natural resources that are inherently dynamic in character. The realized value of medicinal plants to the rural livelihoods of individuals is also not static. For medicinal plant use, it is often easy to decrease or increase the quantity of *Aloe* used, as household social dynamics allow.

8. Conclusions and Recommendations

The limitations and challenges associated with existing orthodox medicine and healthcare services in rural communities justifies the need for viable alternatives for managing childhood diseases. In addition to being cheaper and more accessible, *A. glabrata*, *A. maculata, D. stramonium*, *G. fruticosus, R. tridentata* and *V. karroo* can be viable therapeutic options or substitutes if they are properly prepared and standardized. Nevertheless, a multidisciplinary research approach involving traditional health practitioners, paediatricians, chemists, pharmacists, botanists, farmers and policymakers remains crucial. In particular, the cultivation of the selected plants should be promoted under a participatory management action plan to stimulate the economy of the disadvantaged local communities. Furthermore, low-cost technologies are essential to promote sustainable use. Local communities and other stakeholders working in the medicinal plant sector should be properly registered and formally acknowledged so that strong regulations and norms may be adopted to protect community-based traditional knowledge and intellectual property rights, ensuring equitable benefit sharing.

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