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**STATUS OF MEDICINAL AND AROMATIC PLANTS IN PAPUA NEW GUINEA: A REVIEW**

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**ABSTRACT:**

Medicinal and aromatic plants (MAPs) have a long history of use rooted in local cultures and traditions due to a range of their pharmaceutical, cosmetic, perfumery, dietary and nutritional applications. The medicinal and aromatic plants play a significant role in ensuring health security of millions of people globally. Although a very large segment of the population in Papua New Guinea (PNG) meets its healthcare needs through herbal medicines and products, very little has been done to develop this sector. It is argued that exploitation of MAPs as a source of livelihood is no longer a viable option due to population pressure, over exploitation, conflict of interests in land use and impact of climate change. Nevertheless global demand for herbal supplements and remedies is very high, and given the unique biodiversity and thousands of plants species growing in PNG this sector deserves special attention and effort to promote medicinal and aromatic plants through cultivation supported by adequate research, development and extension activities in order to ensure their better conservation and utilization in trade and industry. Due to geographical location and remoteness, access to health services is limited in several parts of PNG. The use of medicinal plants and traditional medicine is widespread among these communities, thus presenting both challenges and opportunities. PNG has one of the lowest health indicators in the Pacific. The question is how best MAPs can be utilized for improving the health conditions? This paper attempts to assess the current status of production, utilization and commercial prospects of medicinal and aromatic plants in PNG and identify future needs of conservation and opportunities for their development.

**KEYWORDS:** Medicinal, aromatic, plants, traditional medicine, herbal industry, biodiversity

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**INTRODUCTION:**

(Geography, ecology, biodiversity, and economy of PNG)

Lying just south of the equator, 160km north of Australia, Papua New Guinea (PNG) is part of an arc of mountains stretching from Asia, through Indonesia into the South Pacific [1]. PNG is the world's largest and highest tropical island [1]. The country is richly diversified in languages, culture, customs, traditions, native flora and fauna [2]. It is one of the 'last frontiers' which truly defines magnificence and richness of diversity. Geologically, PNG has the highly mountainous, arid to rain forest, coastal swamps to alpine forest areas [2].

The country consists of more than 600 islands, the lowlands (0-1200m) and highlands (1200-2800m). As many as 800 ethnic groups exist, and 800-850 distinct languages are spoken in the country [2, 3, 4]. It is known that close geographical relationship between areas of high biological and language diversity exists and that particular cultural practices and linguistic tradition are compatible with high biodiversity [5, 6, 7].

PNG is the 4<sup>th</sup> mega-bio diverse country in the world [8]. It has 70% of its land covered by tropical rainforest. It covers less than 1% world land mass but contains more than 5% of biodiversity [3,9]. The total number of plants and animal species exceeds 200, 000 species [10]. Scientists estimate that more than half of

the plants and animals found in PNG have yet to be scientifically named. Fortunately, much of this biodiversity has remained intact for thousands of years because of the ruggedness of the terrain that made the interior lands inaccessible. Coupled with low population density it also ensured that these biodiversity was never overexploited.

With more than 30 million hectares of closed tropical forests, PNG ranks 9th among the most forested tropical countries of the world [10,11]. Though estimates of total world species vary dramatically, it is estimated that 15,000 to 20,000 individual species of vascular plants may be found in PNG. Of these, perhaps 60% are endemic to PNG, one of the highest rates of endemism in the world [12]. PNG is home to some of the world's most unique species including the world's largest butterfly, moth, lizard, and crocodile [13]. It is the home of the bird of paradise, the national symbol, crowned pigeons, cassowaries, and many other exotic species. More species of orchids, sugar cane, parrot, pigeon and kingfisher exist in PNG than anywhere else on Earth. It is said PNG is a "cornucopia of ecology" [13].

PNG is a culturally diverse nation consisting of hundreds of distinct tribes. The lives of most of these tribal groups are intimately linked to their environment. They still survive through subsistence farming, food gathering and

hunting. Their food, housing, clothing and ritual materials are still largely obtained from their immediate surroundings. This extended habitation of diverse environs by various tribal groups has led to an especially rich tradition of medicinal plant use in PNG with well over 50% of the population relying exclusively on medicinal plants for health care [14]. The decline of the environment threatens the way of life for many of PNG's tribes.

PNG's economy struggled after gaining independence in 1975 and many of its institutions including national health systems went under-funded [15]. The national economic outlook is now improving, reflecting a flood of First World industries investing in the exploitation of the extensive gold, gas, timber and fishery resources of PNG [15,16]. In 2003 the PNG Gross Development Product (GDP) was under 4 billion USD, in 2013 it is just under 16 billion [16]. The first Liquid Natural Gas (LNG) project is on track to begin exportation in 2014, projected to contribute an additional 8 billion USD to PNG's GDP [16]. However, benefits to PNG's rapidly expanding population of 7 million are slow in materializing. PNG lags behind in almost all indicators of human development including health [17].

Medicinal and aromatic plants (MAPs) are produced and offered in a wide variety of products, from crude materials to processed and packaged products like pharmaceuticals, herbal remedies, teas, spirits, cosmetics, sweets, dietary supplements, varnishes and

insecticides. Global market for MAPs has been growing at seven per cent annually, capitalizing on the growing awareness of herbal and aromatic plants worldwide [18]. A World Bank commentary has observed that "while commercial cultivation of medicinal plants is taking place on a miniscule scale, this activity is poised for 'dramatic growth' in the coming decade and favours organic and mixed cropping to ensure 'good agricultural practices' [19,20]. The use of botanical raw material is in many cases much cheaper than using alternative chemical substances [18]. Importance of MAPs becomes even more critical when we look at the intricate relationship that exists between biodiversity, ecosystem and human health. Nature remains the mainstay of medicines today as half or more of the prescribed medicines come from the natural sources, directly or indirectly [18]. This further emphasizes the need to preserve, protect and develop PNG's abundant natural resources for economic and health benefit of the population. The question that needs to be addressed is whether MAPs could be developed on a sustainable commercial scale for the benefit of all those involved.

#### **MEDICINAL AND AROMATIC PLANTS:**

Aromatic plants

There are an estimated 400 types of essential oils traded in the world with USD 5b in value. Global trade for flowers and fragrances were worth USD 22b in 2010 [21]. However, there

are no commercial or large scale plantings of medical and aromatic plants in PNG, and there is little marketing and trade of these materials. Small scale production of essential oils is limited to domestic markets only. There are hundreds of plant species that are used by indigenous people for sickness and physical ailments, but these plants are not commercialized. They are used mostly by rural people.

A number of plants have commercial potential but government policy and finance is needed to develop an essential oil industry. Although essential oils are not currently produced at commercial scale, an estimated 30 aromatic plant species have been identified for potential development and industrial application in PNG. Some of these are mentioned here.

*Cryptocarya masoy* (Massoia bark): The bark and hardwood contains C-10 lactone, golden colored oil. An experimental pilot plant has been set up in Central Province of PNG to investigate and explore commercial potential of the oil. Massoia lactone has an odour that is described as sweet, coconut meat, creamy, milky and waxy [22].

*Asteromyrtus symphyocarpa* (Waria-waria tree): Wari wari oil is obtained from Waria-waria trees that grow prolifically in PNG's Western province [22,23]. It's a type of melaleuca, and its leaves contain oil with basically the same medicinal qualities as

eucalypt oil. The Australia's science agency CSIRO (Commonwealth Scientific Industrial Research Organization) and Australia Tree Seed Centre (ATSC) in partnership with the PNG National Forest Authority and the PNG Biological Foundation has established a sustainable essential oil industry in Western Province.

The oil is used to treat cough, pains and infections but other claims have also been made about the uses of benefits of the oil locally including solving baldness and curing malaria and so forth but basically the oil is cineole rich oil like medicinal eucalyptus oil and has very similar uses [24]. There are five distillation stills in three villages, but a viable industry is yet to be developed. The Waria-waria oil is already popular in the Port Moresby markets, but it's hoped that eventually the oil can find a wider market and create a viable local industry.

*Santalum macgregorii* (Papua sandalwood): Due to its wide use this tree is overexploited and considered a threatened species [24]. However, measures have been recently introduced for sustainable harvesting and conservation of this tree. Sandalwood oil is a pale yellow liquid and used as general fixative in almost any perfume type.

*Pogostemon cablin* (Patchouli; also called patchouly or pachouli) is a species of plant from the genus *Pogostemon* [24]. It is a bushy herb

of the mint family, with erect stems, reaching two or three feet in height and bearing small, pale pink-white flowers. The heavy and strong scent of patchouli has been used for centuries in perfumes, and more recently in incense, insect repellents, and alternative medicines.

*Aquilaria agallocha* (Agarwood): The tree grows on high altitude. Agarwood is a resinous wood that occurs in tree *Aquilaria agallocha*; the resin produced is rich dark in colour [24].

*Elettaria cardamomum* (Cardamom oil): The plant was introduced in highlands of PNG in 1960s. It is cultivated in high altitude mountainous region of highlands. Small communities are engaged in organic farming of cardamom as part of small enterprise that generates some income for the people [24].

*Tagetes* genus (52 spp.): Essential oil known as tagette for the perfume industry is produced from some of the species. A number of these species abound in PNG [24].

*Morinda citrifolia* (Noni juice and oil): Noni juice and oil is produced from the fruits and root substracts and sold in local markets. There are some large Noni farms in the country that supply raw materials to these producers [25].

*Zingiber officinale* and *Curcuma longa* (Ginger and Turmeric): Ginger and turmeric belong to the family Zingiberaceae and are grown widely

throughout PNG. In both plants the underground stem (rhizome) is the commercial product. There are several pharmacological applications for these species. Both these plants are used in traditional medicines for their medicinal properties [25].

Other plant spp.: *Polygala paniculata* (Indian snake-root), *Euodia* spp., *Cymbopogon citratus* (Lemon grass), *Piper aduncum*, *Piper gibblimum*, *Alipina* spp., *Melaleuca leucadendron*, *Eucalyptus* spp., *Plantifolia vanilla* (Vanilla) [24].

#### **MAPS GENETIC RESOURCES – CONSERVATION, DEVELOPMENT AND GERmplasm COLLECTION:**

Interest and support for the conservation and development of medicinal plants is increasing in all parts of the world including PNG. This is due, in part, to a growing recognition given to the role of medicinal plants in the provision of culturally relevant and affordable health care, in creating sustainable livelihoods and in the vital conservation of biodiversity. This has also drawn the attention of the world community towards the need for creating mechanisms to ensure sustained development of the sector and to allow sharing of information between countries, organizations and agencies. Although plants are widely used in the traditional systems of medicine in PNG it is only recently that some interest is being shown by the private sector and NGOs in this area [26].

Plant genetic resources (PGR) not only form the foundation of agriculture and agricultural research but also of medicinal plants. Requirement for diverse genotypes of medicinal and aromatic plants that give higher yield of specific compounds used in medicine will never cease in developing new varieties [27]. Unfortunately no work is going on in PNG in the area of germplasm collection, characterization, evaluation, etc. However the need and importance of variety development for work in future cannot be underestimated. Also very little effort has been made in variety development, and cultivation of medicinal and aromatic plants. None of the important plants are cultivated for processing or product development or export and commercial development. There is also no Government policy in place for promotion and commercial development of medicinal and aromatic plants at present.

Since the incorporation of National Policy on Traditional Medicine in 2007 [28] however, systematic survey and documentation of medicinal plants has been undertaken and still continuing. Further details are given in the succeeding paragraphs.

#### **CONSTRAINTS AND OPPORTUNITIES:**

PNG health system is built on modern western medicine, though traditional medicine is widely used both in urban and rural areas. There is need to develop herbal industry in PNG to meet

the potential demands in global and domestic market. The necessary growth drivers for development of herbal industry are health concerns, side effects of conventional drugs, higher confidence, cultural acceptability, and competitive pricing. In the past two decades there has been increasing appreciation toward maintaining health with natural products vs. curing disease with chemical drugs [29,30]. There is also growing awareness of side effects of synthetic drugs. In recent years consumers are showing greater confidence in scientifically validated and quality products of traditional medicines. Besides, herbal extracts and powders are comparatively cheaper than synthetic drugs and formulations [29,30].

#### **MEDICINAL PLANTS AND TRADITIONAL MEDICINE PRACTICES IN PNG:**

Traditional medicine is an important part of the health system in PNG. The Government of PNG adopted the National Policy on Traditional Medicine in 2007 [28]. The policy aims to improve the quality and delivery of traditional medicine and its practices and identifies ways of integrating traditional medicine into the country's primary health care system. Traditional healers are permitted to practice at village and district level. Indeed traditional healers and medicinal plants have become important health resources in rural areas, particularly where aid posts and health centres have closed. The use of traditional medicine is very much part of the lives of local communities

throughout the country. Each ethnic group has a long tradition of using plants and other natural materials for treating illnesses. Although no official data exists it is estimated that traditional medicine accounts for almost half of all health care delivered in the country. It is the only form of health care available in some remote parts of the country [31]. The knowledge of traditional medicine is passed on from many generations verbally, and mostly to family members. Some traditional medicine practices are unique and of cultural significance. There is now concerted effort to document and safeguard the traditional knowledge of medicinal plant usage as it is a national heritage. In some areas traditional medical knowledge is still kept secret and cannot be released or shared easily. In general, there is good awareness but there is also a strong perception that traditional medicine is not being utilized to its full potential [31].

Currently medicinal plant preparations are used to treat various ailments such as sexually transmitted diseases, asthma, diarrhoea/dysentery, body/abdominal pain, headaches, boils/sores, tuberculosis, cold/cough, fever/malaria and insect bites [31]. According to a 1999 national report, 80% of the population in PNG are using herbal medicines and traditional medicine therapies [32]. For people living in the most remote parts of PNG, distance from public health services often means that a traditional healer is their only option [32].

There is acceptance of traditional medicine by doctors trained in conventional medicine, and traditional healers do not object to their patients also seeking conventional medical treatment [33]. This mutual tolerance and acceptance contributes to the majority of the population utilising both forms of treatment. Despite the diversity of ethnic groups in PNG, there are several common concepts and beliefs around health and illness, including a universal belief in the power of sorcery, belief in the importance of adherence to customary law, and belief in the healing power of herbs and incantation. It should be noted that the national policy on traditional medicine explicitly excludes the use of sorcery [28].

#### **TRADITIONAL MEDICINE HEALTH CARE INITIATIVES:**

Although the Department of Health in PNG has recognised traditional medicine as a valuable health resource, little has been done with the practitioners at the community level whose services are patronized by seemingly large number of people. As part of the traditional medicine programme of the National Department of Health (NDoH) a series of activities directed at incorporating traditional medicine in the national health system have been initiated in the past ten to twelve years. These include systematic survey of medicinal plants and traditional medicine practices, establishment of medicinal plants database, training of traditional healers in primary care,

traditional healers register and network, research into medicinal plants and development of national herbal formulary [34, 35, 36].

A national office for traditional medicine within the NDoH and the Traditional Medicines Task Force were established in 1999. NDoH officially endorsed medicinal plant use in 2005 through the announcement of a Traditional Medicines Health Care Initiative [17,35]. The Taskforce is now charged with promoting the National Policy on Traditional Medicine (2007) nationwide, selecting 'safe and effective' traditional medicines, developing a training manual for traditional practitioners in primary care, and formalizing Traditional Healer Guilds in the each province [36,37]. Traditional medicine program has featured in National Health Plans since 2001 [17,38]. Cost of traditional medicine is not covered by the government. This policy provides a sound basis for defining the role of traditional medicine in national health care delivery, ensuring that the necessary regulatory and legal mechanisms are created for promoting, maintaining and development of traditional medicine, and that the authenticity, safety, efficacy, quality and rational use of therapies are assured. Besides enabling wider health coverage, introduction of traditional medicine into primary health care will reduce government medical expenditures. This is important at a time of severe financial constraints that the country is facing,

particularly in terms of the funds available for purchase of modern drugs and medical supplies, and for providing human resources to health centres and aid posts. There is limited information on the number of traditional medicine practitioners in PNG. The national traditional medicines database [31] lists over 850 practitioners but the total number may be much higher. There are currently no exclusive traditional medicine training or education programmes at college or university level and no traditional medicine research institute in PNG.

#### **QUALITY AND SAFETY OF TRADITIONAL MEDICINE:**

Currently there is no regulation for herbal medicines or the practice of traditional medicine, though laws relating to the National Policy on Traditional Medicines (2007) are currently in development. The WHO has strongly advocated the use of quality traditional medicines and developed guidelines for member countries to adapt [29]. The Traditional Medicines Database, first started in 1999, holds details on medicinal plants and traditional medicines, and is viewed as a national resource. The Traditional Medicines Task Force, established by the NDoH in PNG in 2004, has been tasked to identify candidate herbal medicines from the database for inclusion in the primary health care formulary. Herbal medicines are sold in local markets with medical, health and nutrient content claims.

PNG has no pharmacopoeia. However, *Medicinal Plants in Papua New Guinea* written and compiled by Rai and colleagues was published in 2009 with support from the WHO regional office. This publication describes traditional uses of 126 medicinal plants [25]. The tradition and culture of using herbs for variety of sicknesses is well entrenched in communities across Bougainville, an autonomous region of PNG. Recent publications by Rai et al [39, 40, 41] have given account of some of the commonly used plants in traditional medicine in Bougainville and highland regions of the country.

The lives of most of the tribal groups in PNG are intimately linked to their environment. This extended habitation by various tribal groups of diverse environs has led to an especially rich tradition of medicinal plant use in PNG. At least 80% of Papua New Guineans use traditional medicines, especially in rural settings where HIV infection is most prevalent [42]. Although many of the early botanical expeditions collected notes on traditional use, they have not been systematically assessed with respect to medicinal records, nor disseminated.

The National Health Plan of PNG, 2001-2010, adopted by the NDoH, created a Traditional

Medicines Working Group to assist in the development of traditional medicines in the country. As an outcome of this early work the University of Papua New Group initiated a country-wide survey on traditional medicine practice, the collection of medicinal plant voucher samples, and developed the above mentioned database. The database provides the Taskforce with validated information concerning particular medicinal plant uses. The database contains comprehensive information on up to 4000 traditional medicines derived from 1000 plant species. The database is dedicated to documentations and preservation of traditional knowledge concerning medicinal plant use in PNG and to serve as repository of indigenous knowledge in traditional medicine [31]. It is also used to identify safe and effective traditional medicine practices and promote their usage in the community.

There are four major categories in the database: prescription database, chemistry and pharmacology database, photo-Image database, and practitioner database. Medicinal plants of commercial potential are listed in Table 1, and the most commonly used plants utilized in PNG traditional medicine are listed in Table 2 [31].

**Table 1:** Distribution of medicinal plants of commercial potential in PNG

<b>Plant species</b>	<b>Region in PNG</b>	<b>Name of oil</b>
<i>Cryptocaria massoy</i>	All coastal regions	Massoia oil
<i>Canaga odorata</i>	All coastal regions	Canaga
<i>Jasminum sp.</i>	All coastal regions	Jasmine
<i>Drimis peperita</i>	Tabubil and some highlands region	Drimis
<i>Pongostemon cablin</i>	Most regions of PNG	Patchouli
<i>Piper nigrum</i>	Most regions of PNG	Pepper
<i>Kaempfera sp.</i>	Central province	Kaempfera
<i>Santalum macgrogreii</i>	Central province	Sandalwood
<i>Aquilaria sp.</i>	Most coastal provinces	Eaglewood
<i>Euodia hortensis</i>	Many provinces of PNG	Euodia
<i>Rosa damacena</i>	Cooler parts of highlands	Rose
<i>Polyanthus tuberosa</i>	All coastal regions	Tuberose
<i>Mentha sp.</i>	Highlands	Mint
<i>Curcuma longa</i>	All coastal regions	Turmeric
<i>Elettaria cardamomum</i>	Most parts of PNG	Cardamom
<i>Acorus calamus</i>	Highlands	Acorus
<i>Piper gibbilimum</i>	Highlands	Gibbilimbol
<i>Melaleuca platyphylla</i>	Western province	Melaleuca

**Table 2:** The most common 100 medicinal plants used in PNG traditional medicine\*

<i>Abelmoschus manihot</i>	<i>Derris elliptica</i>	<i>Morinda citrifolia</i>
<i>Abrus precatorius</i>	<i>Desmodium umbellatum</i>	<i>Ocimum basilicum</i>
<i>Acalypha wilkesiana</i>	<i>Dioscera alata</i>	<i>Pandanus tectorius</i>
<i>Ageratum conyzoides</i>	<i>Dioscorea bulbifera</i>	<i>Pangium edule</i>
<i>Alstonia scholaris</i>	<i>Eleusine indica</i>	<i>Paspalum conjugatum</i>
<i>Alstonia spectabilis</i>	<i>Endospermum formicarium</i>	<i>Passiflora foetida</i>
<i>Angiopteris evecta</i>	<i>Endospermum medullosum</i>	<i>Pedilanthus tithymaloides</i>
<i>Areca catechu</i>	<i>Epipremnum pinnatum</i>	<i>Persea americana</i>
<i>Artocarpus altilis</i>	<i>Erythrina variegata</i>	<i>Pipturus argenteus</i>
<i>Asplenium nidus</i>	<i>Euodia hortensis</i>	<i>Plectranthus scutellarioides</i>
<i>Averrhoa carambola</i>	<i>Euphorbia hirta</i>	<i>Polygala paniculata</i>
<i>Bidens pilosa</i>	<i>Fagellaria indica</i>	<i>Pometia pinnata</i>
<i>Bixa orellana</i>	<i>Ficus adenosperma</i>	<i>Premna obtusifolia</i>
<i>Breynia cernua</i>	<i>Ficus copiosa</i>	<i>Premna serratifolia</i>
<i>Calophyllum inophyllum</i>	<i>Ficus septic</i>	<i>Psidium guajava</i>
<i>Capsicum annum</i>	<i>Ficus wassa</i>	<i>Pterocarpus indicus</i>
<i>Carica papaya</i>	<i>Flagellaria indica</i>	<i>Ricinus communis</i>
<i>Cassia alata</i>	<i>Gnetum gnemon</i>	<i>Rungia klossii</i>
<i>Casuarina equisetifolia</i>	<i>Hibiscus rosa-sinensis</i>	<i>Scaevola tacadda</i>
<i>Casuarina papuana</i>	<i>Hibiscus tiliaceus</i>	<i>Sida rhombifolia</i>
<i>Catharanthus roseus</i>	<i>Homalium foetidum</i>	<i>Solanum torvum</i>
<i>Centella asiatica</i>	<i>Hornstedtia scottiana</i>	<i>Solanum tuberosum</i>
<i>Citrus limon</i>	<i>Imperata cylindrical</i>	<i>Sphaerostephanos alatellus</i>
<i>Cocos nucifera</i>	<i>Inocarpus fagifer</i>	<i>Sphaerostephanos unitus</i>
<i>Codiaeum variegatum</i>	<i>Ipomea pes-caprae</i>	<i>Sterculia ampla</i>
<i>Coleus blumei</i>	<i>Jatropha curcas</i>	<i>Syndrella nodiflora</i>
<i>Commelina paleata</i>	<i>Kalanchoe pinnata</i>	<i>Syzygium malaccense</i>
<i>Cordyline terminalis</i>	<i>Laportea decumana</i>	<i>Terminalia cattapa</i>
<i>Costus speciosus</i>	<i>Macaranga aleuritoides</i>	<i>Timonius timon</i>
<i>Crinum asiaticum</i>	<i>Mangifera indica</i>	<i>Vitex trifolia</i>
<i>Curcuma longa</i>	<i>Manihot esculenta</i>	<i>Wedelia biflora</i>
<i>Cyclandophora laurina</i>	<i>Merremia peltata</i>	<i>Zingiber officinale</i>
<i>Cymbopogon citratus</i>	<i>Metroxylum sagu</i>	
<i>Cyperus rotundus</i>	<i>Mikania micrantha</i>	

\* Based on data obtained from the National Database on PNG Traditional Medicine [Ref: 31]

**FUTURE THRUST:**

Rising consumer interest in use of natural and organic products, sustained demand for medicinal and aromatic plants worldwide [43] and growing acceptance of alternative and complimentary medicines by health policy makers make it prudent for country like PNG to formulate policies and plans to use these resources for economic and health benefit of its people. Scientifically validated and standardized herbal products are in great demand and data are available to develop some suitable products from PNG herbs [37,44].

Using proprietary information accumulated in the National Database on Traditional Medicine in PNG it is possible to identify effective herbal preparations for range of conditions such as energy/wakeup, relaxation/sleep aid, HIV, pneumonia, cough suppressant, topical antibiotic/antifungal, pain or headache, fever, etc. PNG offers huge scope for development of small, medium and large scale industrial production of medicinal and aromatic plants. Timber logging which is one of the main income generation activities at present is detrimental to the sustainability of flora and is impacting adversely on ecology and biodiversity of the land [12]. It is incumbent upon the relevant Government agencies and departments\*\* to formulate policies and action plans to address this important but hitherto neglected area.

There is also scope for private sector to explore and engage in economic ventures utilizing medicinal and aromatic plants. Commercial production of some of these plant species will generate much needed income for village communities, and also help conserve valuable plant resources.

**CONCLUSION:**

Global herbal supplements and remedies market is forecast to reach US \$107 billion by the year 2017 [30]. PNG is known as a treasure house of valuable medicinal and aromatic plants [45]. It is a small nation with rich biodiversity. PNG has an estimated 20,000 vascular plant spp. that offers tremendous opportunity for exploration, cultivation, production, and commercialization of plant products [23]. So far little has been done in this regard. Government support in establishing herbal industry, cooperation and collaboration from private sectors, government agencies, research institutions, and universities are needed to develop this sector.

It is important that valuable plant species are not only conserved but also promoted for commercial cultivation in order to meet the increasing demand especially in the export markets. Efforts should be made to develop suitable herbal products from indigenous plant species with in-built quality control and standardization measures. It is believed that production and accessibility to quality herbal

products within PNG will have positive impact in improving health standards of its people. There is demand locally and overseas for quality herbal products. PNG, with its rich traditional knowledge and plant resources, need to harness this potential.

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