



Cultivation of medicinal plants in developing nations: means of conservation and poverty alleviation

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Abstract: Plants, whether wild or domesticated are fundamental components of ecosystems on earth. They form the productive bases and the physical structures, support diversity of animals and other organisms. Human economies are highly dependent on the plants for supplies of material resources, such as food, housing, fibre, construction materials, fuel, craft materials and medicines. The nature of the plant cover significantly influences the quality of the climate, the availability of water supplies and the stability of the soil. How people use and manage wild plant resources will significantly influence the sustainability of their livelihoods and the conservation of their diversity. Collection is the major ways of harvesting medicinal plants in the wild and this had significant impact on both the ecosystem and the survival of such plant. Cultivation of highly valued medicinal plants should be creating new dimension in the field of agriculture in developing nations. The need for developing countries to apply technologies and techniques of food crop production to program cultivation of medicinal plants within the cropping system in order to improve the medicinal value of such plant.

Keywords: Medicinal plants; Cultivation; Cropping Systems; Sustainability; Ecosystems.

Introduction

Medicinal plants contribute significantly to the rural livelihoods. Apart from traditional healers practicing traditional medicine, more people than ever are involved in collecting, trading and utilizing medicinal plants. The widespread use of medicinal plants in traditional medicines (TM) in developing countries including Nigeria is largely due to the diverse resource base, the flexibility, easy accessibility and affordability, particularly the rural poor. Medicinal plants have therefore been considered a healthy source of life for the people who are able to harvest them from the wild to meet their primary health care needs. The result of the increased demand in both local and international markets as well as bio-prospecting activities searching for sources of new drugs is a source of great concern. Karki (2002) estimated that 95 % of Medicinal and Aromatic Plants (MAPS) in developing countries are harvested and collected in wild. Ahenkan and Boon (2008) observed that the very foundation upon which the medicinal plant species and the traditional

health care system survive is threatened by deforestation, population growth, urbanization. The difficulties experienced in the collection of plants from forest and the problems encountered there in together with heavy demand of medicinal plants necessitate domestication of medicinal plants. Canter *et al.* (2005) reported that some protection given to medicinal plants could be achieved through regulation and the introduction of sustainable wild harvesting methods, but the domestic cultivation is an option that could both reduce pressure on wild populations and solve some of the problems inherent in the production of herbal medicines. These according to Carter *et al.* (2005) include species misidentification, genetic and phenotypic variability, variability and instability of extracts, and toxic components and contaminants. Cultivation offers the opportunity to optimize yield, achieve a uniform, high-quality product and control in every stage of the production process. It might also allow us to modify concentrations of biologically important compounds through the manipulation of growing environments, through traditional

selective breeding methods and through the application of modern biotechnology. This paper hopes to identify farming system in which medicinal plants could be incorporated and to draw lessons on which to build further research and policy development. There is indication that medicinal plants could be planted in the lower strata of multistrata systems such as homegardens (Rao *et al.*, 2004). This paper hopes to identify farming system in which medicinal plants could be incorporated and to draw lessons on which to build further research and policy development.

African Agricultural Production Systems

African farmers pursue a wide range of crop and livestock enterprises that vary both across and within the major agro-ecological zones. Food production and food security in Africa depend on many different systems, unlike other regions of the world where the contribution to food production and food security is based on a limited number of systems. Diversity is the norm in African farming systems. Even at the level of the individual farm unit, farmers typically cultivate 10 or more crops in diverse mixtures that vary across soil type, topographical position and distance from the household compound. The farming systems provide a snapshot of dynamic systems that are constantly evolving. Both endogenous factors (household goals, labour, technologies in use and the resource base) and exogenous factors (market development, shifts in demand, agricultural services and policies, the dissemination of new technologies and the availability of market and policy information) drive the evolution of individual farms and, collectively, the overall farming system Dixon *et al.* (2001).

Generally, farming system can be classified based on economic of production (commercial or subsistence farming), water supply (rainfed or irrigated farming), system of production (collecting, ley, sole cropping, mix or multiple cropping). In the developing countries, agricultural production involved traditional subsistence with mono cropping, multiple cropping and livestock management. The traditional agricultural system of crop production in the most de-

veloping countries and Asia are based on growing crops in mixtures, a system most commonly referred to as mixed cropping or intercropping (Osiru, 1982). Intercropping has long been recognized as a common practice among subsistence farmers in the traditional semi-intensive system of agriculture due to the flexibility of labour use and less risk. The concept, according to Willey (1979) is to bring together, crops with different maturity time, architecture, nutrient requirement etc into a mixture at the same time, under the same management for maximum utilization of nature for the benefit of man. When two or more crops are growing together, each must have adequate space to maximize complementarily between them. The predominance of intercropping, among tropical farmers cannot be overemphasized. The failure of different agricultural policies introduced by various governments in most of the developing countries to improve productivities was partly because most of the introduced modern technology adopted sole cropping (Elemo and Mabbayad, 1980). There has been a great awareness that most of these introduced technologies are contrary to the farmers' production practice. Osiru (1982) and Richards (1983) indicated that the reasons why the peasant farmers in Africa are used to intercropping are the several benefits which they derived. Among the economic and social benefits of intercropping are provision of favourable microclimate, possibility of lower labour requirement, stability of production, diversity of crops produced and higher productivity per unit area (Osiru, 1982). Fortin and Pierce (1996) indicated that the interest in intercropping is growing worldwide because of its potential for increasing whole field productivity.

Good Agricultural Practices according to Food and Agriculture Organization (FAO) of the United Nations are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economical, social and environmental sustainability. Good agricultural practice (GAPs) may be applied to a wide range of farming systems and at different scales. They are applied through sustainable agricultural methods, such as integrated pest management,

integrated fertilizer management and conservation agriculture. They rely on four principles:

- Economically and efficiently produce sufficient (food security), safe (food safety) and nutritious food (food quality)
- Sustain and enhance natural resources;
- Maintain viable farming enterprises and contribute to sustainable livelihoods;
- Meet cultural and social demands of society.

Applications of GAPs provide the opportunity to assess and decide on which farming practices to follow at each step in the production process. For each agricultural production system, they aim at allowing a comprehensive management strategy, providing for the capability for tactical adjustments in response to changes. The implementation of such a management strategy requires knowing, understanding, planning, measuring, monitoring, and record-keeping at each step of the production process. Adoption of GAPs may result in higher production, transformation and marketing costs, hence finally higher costs for the consumer. To minimize production costs and maintain the quality of agricultural food and medicinal plants (ACIAR 2007). Good agricultural practices require maintaining a common database on integrated production techniques for each of the major agro-ecological area, thus to collect, analyze and disseminate information of good practices in relevant geographical contexts. The quality assurance of the agricultural products of medicinal plant is also the ultimate (WHO 2003).

Why cultivating medicinal plants?

Collection is an agricultural system in which uncultivated plants are harvested regularly or irregularly in the wild. Collection, simple processing and trading of medicinal plants contribute significantly to the cash income of the poor small holder farmers and especially women in developing countries (Karki *et al.*, 2003). Studies carried out in India (Regmi and Bista, 2002), indicated that from a single district of Pithoragarh in Uttaranchal State of India, more than 1300 tons of medicinal and aromatic plants (MAPs) are collected and traded annually, most

of them illegally. Unsustainable and large scale harvesting of MAPs from the natural habitats without providing equitable benefit to the local people and government is of grave concern to all. Cultivation of medicinal plants has pharmacological advantages over wild-collection. Wild collections normally vary in quality and composition due to environmental and genetic differences. Cultivation also greatly reduces the possibilities of misidentification and adulteration especially endangered species.

In many developing countries, medicinal plants were collected from the wild vegetation. However, in response to the combined impacts of dwindling supplies due to overexploitation of the natural resources and increasing demands due to population growth and growing global markets, threat from increase in human population leading to increase in human activities such as commercial agriculture, urbanization, human disturbance and deforestation, many plants species are facing the threat of extinction (Prasad, 2009). Wild habitat became locked in parks and reserves making it difficult for people to collect the plant materials which they need until they search for a long time within long distance. In Ghana the activities of plant collectors have revealed that plant species that used to be obtained within short walking distance now have to be sourced several kilometers away owing to development of human settlements, farming activities, bush burning and other destructive human activities. Kempanna (1974) has earlier documented about 2,700 collections of medicinal plants in India while Schmelzer and Gurib-Fakim (2008) recorded 2,500 species of plants in Africa which have been found to have medicinal application in addition to another use. All these collections, the largest number are gathered from the wild while only a few are cultivated to a noteworthy extent (Rehm and Espig, 1991). The intensive harvesting of wild medicinal plants due to the increasing use has in many places resulted in overexploitation, and forms a serious threat to biodiversity in the region (Wiersum *et al.*, 2006). Several studies attest to a trend of increasing harvesting pressures on traditional supply areas linked to a growing shortage in supply of popular medicinal plant species. The current demand for certain taxa exceeds supply, with traders reporting acute short-

ages and price increases of these. As a result, several plant species have been exploited to such an extent that they are seldom found in unprotected areas (Cunningham 1991b; 1991a; Williams 2004).

The best way to provide the plants needed for medicinal purposes is to cultivate them. This is far better than collecting them from the wild since it thus not deplete the wild stocks, the declining habit of native plants can no longer support the expanding market for medicinal plant products. In the case of rare, endangered or over-exploited species, cultivation is the only way to provide material without further endangering the survival of those species.

Bringing medicinal plants into cultivation

Craker (2008) found that in America, the use of plants as medicine was formerly considered a primitive concept unacceptable in a modern nation with an enviable medical system, a reconsideration of the contributions that medicinal plant material can offer a contemporary health system has led to fresh views about medicine and plants. This reassessment of medicinal plants has stimulated cultivation of new species and led to increases in production of previously cultivated traditional species. Canter (2005) reported that more than 80% of the world's population in developing countries depends primarily on herbal medicine for basic healthcare needs; the use of herbal medicines in developed countries is growing and 25% of the UK population takes herbal medicines regularly. Around two-thirds of the 50 000 different medicinal plant species in use are collected from the wild, and in Europe only 10% of the medicinal species used commercially are cultivated. Jäger and Van Staden (2000) found that traditional medicine is an important part of healthcare in southern Africa. Most drugs are prepared from plants, all of which are collected from the wild. Vines (2004) reported that all these activities on medicinal plants may lead to diminishing populations, extinctions and habitat degradation as many as 10000 medicinal species may be endangered in Europe.

It is imperative to develop the tradition of cultivating medicinal plants within the tradition-

al cropping system to avoid extinction of most of the plants. There should be a holistic approach to develop agronomic practices within the traditional cropping system also to coordinate the local communities in establishing nurseries where the medicinal plants can be raised for commercial purposes. Although research in medicinal plants in Africa has generated a lot of information, information on the incorporation of medicinal plants into the traditional cropping system and the evaluation of the therapeutic values of these plants under cultivation are scattered and their impact on health and economic remain limited.

Cultivation of medicinal and aromatic plants (MAPs) as a means of conservation

These practices include domestication; beliefs on sacredness of trees; beliefs on sacred forests; respect of cultural forests; protection of plants at the burial sites; selective harvesting; secrecy; collection of dead wood for firewood; and use of energy saving traditional stoves. But medicinal plants are increasingly vanishing, not only because they are highly demanded for primary health care, but also because they cater for several other purposes such as trade, food, timber, firewood and building poles. Land clearing (for agriculture, settlements and other developments) and accidental and deliberate fires also contribute to loss of these species.

It is certainly a long way between the documents and the practical implementation of the proposed actions. Various conservation methods were mentioned in the past by many authors and are being repeated at present. These methods include protection of wild species *in-situ*, cultivation in botanical gardens, collection of germplasm, for establishment of germplasm banks, public information campaigns and others.

Cultivation has pharmacological advantages over wild-collection. Wild collections normally vary in quality and composition due to environmental and genetic differences. Cultivation also greatly reduces the possibilities of misidentification and adulteration. In cultivation, the variation and the resulting of uncertainty therapeutic benefit is much reduced.

Indigenous knowledge (IK) (2006), in documenting the conservation of medicinal plants in Central America and the Caribbean noted

summarized the advantages and disadvantages of cultivation of MAPs as indicated in the Table 1.

Table 1: Wild harvesting versus cultivation of medicinal and aromatic plants: A summary of advantages and disadvantages

For species and ecosystems it is better to ...	
wild harvest because ...	cultivate because ...
<ul style="list-style-type: none"> ❖ it puts wild plant populations in the continuing interest of local people ❖ it provides an incentive to protect and maintain wild populations and their habitats and the genetic diversity of MAP populations <p>but ...</p> <ul style="list-style-type: none"> ❖ uncontrolled harvest may lead to the extinction of ecotype and even species ❖ common access to the resource makes it difficult to adhere to quotas and the precautionary principle ❖ in most cases knowledge about the biology of the resource is poor and the annual sustained yields are not known ❖ in most cases resource inventories and accompanying management plans do not exist 	<ul style="list-style-type: none"> ❖ it relieves harvesting pressure on very rare and slow-growing species which are most susceptible to threat <p>but ...</p> <ul style="list-style-type: none"> ❖ devaluates wild plant resources and their habitats economically and reduces incentive to conserve ecosystems ❖ narrows genetic diversity of gene pool of the resource because wild relatives of cultivated species become neglected ❖ it may lead to conversion of habitat for cultivation ❖ cultivated species may become invasive and have negative impacts on ecosystem ❖ reintroducing plants can lead to genetic pollution of wild populations
The market demands ...	
wild harvested plants because ...	cultivated material because ...
<ul style="list-style-type: none"> ❖ it is cheaper since it does not require infrastructure and investment ❖ many species are only required in small quantities that do not make cultivation economically viable ❖ for some plant parts extra-large cultivation areas are required (e.g. <i>Arnica</i> production for flowers) ❖ successful cultivation techniques do not exist, e.g. for slow growing, habitat specific taxa ❖ no pesticides are used ❖ it is often believed that wild plants are more powerful <p>but ...</p> <ul style="list-style-type: none"> ❖ there is a risk of adulterations ❖ there is a risk of contaminations through non-hygienic harvest or post-harvest conditions 	<ul style="list-style-type: none"> ❖ it guarantees continuing supply of raw material ❖ it makes reliable botanical identification possible ❖ genotypes can be standardized or improved ❖ quality standards are easy to maintain ❖ controlled post-harvest handling is possible ❖ production volume and price can be agreed for longer periods ❖ resource price is relatively stable over time ❖ certification as organic production is possible <p>but ...</p> <ul style="list-style-type: none"> ❖ it is more expensive than wild harvest ❖ it needs substantial investment before and during production
From a perspective of the people it is better to ...	
wild harvest because ...	cultivate because ...
<ul style="list-style-type: none"> ❖ it provides access to cash income without prior investment 	<ul style="list-style-type: none"> ❖ it secures steady supply of herbal medicines (home gardens)

- ❖ it provides herbal medicines for health care needs
 - ❖ it maintains the resources for rural populations on a long-term basis (if done sustainably)
- but ...**
- ❖ unclear land rights create ownership problems
 - ❖ this income and health care resource is becoming scarce through over-harvesting

- ❖ it provides in-country value-adding
- but ...**
- ❖ capital investment for small farmers is high
 - ❖ competition from large scale production puts pressure on small farmers and on wild harvesters
 - ❖ benefits are made else-where and traditional resource users have no benefit return (IPR)

Sourced IK 2006

Cultivation of medicinal plants especially high value medicinal plants is creating new dimension in the field of agriculture. To improve and conserve medicinal biodiversity, India has been reported (Alternative Medicine News, 2008) to be making efforts for cultivation, collection, characterization, planned hybridization programs for improvement of the plant species and conservation medicinal plants by restoring their genetic resources for commercial cultivation. Plant breeders of medicinal plant play key roles in improvement of medicinal plants because they care for stable produce, uniform plant growth and maturity, economic to grow and of good quality.

Inclusion of Medicinal Plants in cropping Systems

Some of the practical applications integrating medicinal plants into traditional farming systems have taken an obligate relationship in backstopping upland agriculture. South Asian states have a tradition of practicing mixed farming systems that include herbal plants and therefore, cultivation of medicinal plants especially applying organic and certified farming concepts has a greater scope in the region. Other important opportunities and advantages of cultivating MAPs include ease of their incorporation in the existing cropping systems due to availability of a large number of species and choice of plant types such as trees, shrubs, forbs, vines and their suitability to grow in different eco-physical conditions. Cultivation of carefully selected species as a mixed, inter or companion crop in agro and farm forestry conditions following a soil-improving crop rotation is highly feasible livelihood enhancing activities in South Asia. However, this will require an improved input

and service delivery system including marketing, and post harvest technologies. Cultivation needs to be done on a business platform by a chain of small and microenterprise-based groups and individuals. In order to achieve an economy of scale and desired impact, it may need to be concentrated in selected pockets in an intensive manner as cluster of activities and micro-enterprises.

In cultivation, the variation and the resulting of uncertainty therapeutic benefit is much reduced. There is no reason why traditional crop-breeding methods should or could not be applied to medicinal herbs grown domestically. The basic principles which include selection, multiplication and breeding only from individual genotypes showing the desired characteristics could be further hybridized to make crosses between specific genotypes, bearing in mind the desired combination of characters and an understanding of genetics.

Direct manipulation of DNA sequences to alter gene expression in medicinal plants is an area ripe for expansion. The primary target for trait manipulation in medicinal plants is the content of active compounds, but to develop them as crops basic agronomic characteristics related to uniformity, stability, growth and development, and resistance to biotic and abiotic stresses also need to be improved.

The commercial viability of bringing medicinal plants into domestic cultivation and the potential for increased use of modern biotechnologies are likely to be strongly influenced by popular perceptions both of herbs and of biotechnology. One of the main attractions of herbs as medicines is their 'natural' status and the associated, but erroneous, view that they must therefore be safe

and intrinsically good for us. In stark contrast is the popular view of crops bred with the assistance of molecular biology and modern farming methods as highly 'unnatural'. This is particularly so for transgenic plants, and it is probable that organic growing methods will be received favourably by purchasers of cultivated medicinal plant extracts. However, it is entirely possible to grow selected or genetically modified varieties using organic growing methods.

Challenges in the cultivation of medicinal plants

Pieters and Vlietinck (2005) observed danger involved if medicinal herbs are increasingly brought into domestic cultivation, then wild harvested plants would enjoy an increased cachet and commercial value, and non-sustainable harvesting methods would continue. It is perhaps worth considering that any form of cultivation or wild harvesting of plants is bound to involve the application of selective forces, conscious or unconscious, on the part of the grower or harvester. In the case of wild harvesting, continual selection of the largest wild-growing individuals or those with the traits considered desirable from a medicinal point of view, if it involves destruction of the whole plant or its reproductive organs, will inevitably lead to a degradation of the wild population. Though, it is difficult to use medicinal plants on a large scale without modifying the characteristics of the plant populations available, be they wild or domesticated. If medicinal herbs are brought into cultivation, then it will at least attempt to modify the characteristic of the population in a controlled fashion, and at the same time attempt to conserve wild populations.

In conclusion, medicinal plants have always been part of mans' life on earth and there is a close relationship between plants and human beings. Man depends on plants for his existence and this relationship must be sustainable. Herbs have saved man's life on innumerable occasions and for these reasons their over-use concerns everyone. Plant-derived medicines have greatly provided the models for, a significant proportion

of western drugs. Commercially-proven drugs used in modern medicine were initially used in crude form for other purposes that suggested potentially useful biological activity for centuries; the forests have been the source for procurement of medicinal plants. During the last few decades the area under forests has considerably decreased while the demand for raw material of medicinal plant origin has been increasing due to increased number of users due to resurgence of public interest in Homoeopathy. Therefore, the forest resources are not able to meet the full requirement of medicinal plants and herbs. Further, as a result of continuous exploitation of these plants in forests and absence of major regular development programs in the forestry and agriculture sectors, a number of species of these plants are reported vulnerable to extinction, and various sorts of prohibitions have been placed for use of a number of medicinal plants even for medicinal use.

References

- Ahenkan, A. and Boon, P. 2008. Enhancing Food Security, Poverty Reduction and Sustainable Forest Management in Ghana through Non-timber Forest Products Farming: Case Study of Sefwi Wiawso District, published online by GRIN Publishing at www.grin.com/de/preview/html (Retrieved 15 May, 2010)
- Alternative Medicine News 2008. *India to Step up Allocation for Cultivation of Medicinal Plants* Tuesday, May 13, 2008
- Australian Centre for International Agricultural Research (ACIAR). 2007. "Research that works for developing countries and Australia". <http://www.aciar.gov.au/publication/publicationsbydownload>. Retrieved 25 November 2007.
- Canter, P. H. 2005 Bringing medicinal plants into cultivation. *Focus Altern Complement Ther* 10: 167–168
- Canter, P. H; Thomas, H. and Ernst, E. 2005. Bringing medicinal plants into cultivation: opportunities and challenges for

- biotechnology. *Trends Biotechnol* 23: 180–185.
- Craker, L.E. 2008. A perspective on cultivation of medicinal plants in America. *Acta Horticulturae* 765:57-66
- Cunningham, A.B. 1991a. Development of a conservation policy on commercially exploited medicinal plants: a case study from southern Africa. In: Akerele, O., Heywood, V. and Syngé, H. eds. *The conservation of medicinal plants: proceedings of an international consultation 21-27 March 1988, Chiang Mai, Thailand*. Cambridge University Press, Cambridge, 337-358.
- Cunningham, A.B. 1991b. The herbal medicine trade: resource depletion and environmental management for a hidden economy. In: Preston-Whyte, E. and Rogerson, C. eds. *South Africa's informaleconomy*. Oxford University Press, Cape Town, 196–206.
- Dixon, J., Gulliver, A. and Gibbon, D. 2001. Farming systems and poverty: Improving farmers livelihoods in a changing world. *Food and Agriculture Organization, Rome, and World Bank, Washington, DC*
- Elemo, K.A. and B. B. Mabbayad 1980. Effect of sowing date on upland rice/peanut inter-cropping. *The Philippine Journal of Crop Science* 5 (1): 22-29
- Fortin, M.C. and Pierce F.J. 1996. Leaf azimuth in strip-intercropped corn. *Agronomy Journal*, Madison, 88(1): 6-9
- Indigenous Knowledge (I.K.) 2006. Conservation of Medicinal Plants in Central America and the Caribbean <http://www.worldbank.org/afr/ik/default.htm> No. 93
- Jäger A. K. and Van Staden J. 2000. The need for cultivation of medicinal plants in southern Africa *Outlook on Agriculture*, 29(4): 283-284
- Karki, M. B. 2002. Organic Conversion & Certification: A Strategy for Improved Value-Addition and Marketing of Medicinal Plants Products in the Himalayas; Paper presented at the Regional Workshop at Wise Practices and Experimental Learning in the Conservation and Management of Himalayan Medicinal Plant; Kathmandu, Nepal December 15-20, 2002
- Karki, M., Tiwari, B., Badoni, A. and Bhattarai, N. 2003. Creating Livelihoods Enhancing Medicinal and Aromatic Plants based Bio-diversity-Rich Production Systems: Preliminary Lessons from South Asia Oral Paper Presented at *The 3rd World Congress on Medicinal and Aromatic Plants for Human Welfare (WOCMAP III)* 3-7 February 2003, Chiang Mai, Thailand.
- Kempanna, C. 1974. Prospects for Medicinal Plants in Indian Agriculture. *World Crops*. 26: 166-168.
- Osiru, D.S.O. 1982. Intercropping: a review of the possible advantages. *Proceedings of the Indian Statistical Institute International conference on Frontiers of Research in Agriculture*. Calcutta, September 27-October 1, 1982. pp 304-320
- Pieters, L. and Vlietinck. A. J. 2005. Bioguided Isolation of Pharmacologically Active Plant Components, Still a Valuable Strategy for the Finding of New Lead Compounds? *J. Ethnopharmacol.* 100(1-2): 57-60.
- Prasad, P. 2009. Impact of cultivation on active constituents of the medicinal plants *Podophyllum hexandrum* and *Aconitum heterophyllum* in Sikkim *PGR Newsletter FAO Biodiversity* 124: 33 – 35.
- Rao, M. R., Palada, M. C. and Becker, B.N. 2004. Medicinal and aromatic plants in agroforestry systems. *Agroforestry Systems*, 61 (1), 107-122.
- Regmi S. and Bista, S. 2002. Best Practices in Collection and Cultivation of Medicinal Plants for Sustainable Livelihoods in Himalayan Communities; Paper presented at the Regional Workshop at Wise Practices and Experimental Learning in the Conservation and Management of Himalayan Medicinal Plant; December 15-20, 2002; Kathmandu. CECI- Nepal.
- Rehn, S. and Espig, G. 1991. The cultivated plants of the tropics and subtropics. *CTA and Verlag. Scientific Books*. Germany. pp 560

- Richards, P. 1983. Ecological change and politics of land use. *African Studies Review* 26:1-72
- Schmelzer, G.H. and Gurib-Fakim, A. (Editors), 2008. Medicinal plants of Tropical Africa Conclusions and recommendations based on PROTA 11(1): 'Medicinal plants' CTA 791 pp
- Vines, G. 2004. Herbal harvests with a future: towards sustainable sources for medicinal plants, Plant life Integration; www.plantlife.org.uk.
- Wiersum, K. F., Dold, A. P., Husselman, M. and Cocks, M. 2006. Cultivation of medicinal plants as a tool for biodiversity conservation and poverty alleviation in the Amatola region, South Africa in *R.J. Bogers, L.E. Craker and D.Lange (eds), Medicinal and Aromatic Plants*, 43-57.
- Willey, R.W. (1979) Resource use in intercropping systems. *Agricultural Water Management*, Amsterdam, 17: 215-231
- Williams, V. L. 2004. Trade and socio-economic value of forest and woodland reserves within the medicinal plant market in Johannesburg. In: Lawes, M.J., Eeley, H.A.C., Shackleton, C.M., et al. eds. *Indigenous forests and woodlands in South Africa: policy, people and practice*. University of KwaZulu-Natal Press, Scottsville, 439-472
- World Health Organization (WHO) 2003. Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants. Pp 80 <http://apps.who.int/medicinedocs/en/d/Js4928e/>