Impact of Cultivation and Collection on the Conservation of Medicinal Plants: Global Trends and Issues

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Abstract
The relationship between in situ and ex situ conservation of species has implications for local communities, public and private land owners, entire industries and, of course, wild species. Identifying the conservation benefits and costs of the different production systems for medicinal and aromatic plants (MAP) should help guide policies as to whether species conservation should take place in nature or the nursery, or both.

In all countries, the trend is towards a greater demand for cultivated material. Standardized quality and quantity of production is the main rationale for bringing a species into cultivation. However, high input costs are a substantial limitation of cultivation as long as sufficient volumes of material can still be obtained at a lower price from wild harvest. For economic reasons, the majority of MAP species will therefore continue to be harvested wild. For them, the priority conservation option is sustainable harvest from wild populations.

There are important social, economic, and ecological benefits from wild harvest. Wild harvesting of medicinal plants is a chance for the poorest members of society, particularly those who do not have access to farmland, to make at least some cash income. If collectors and collecting communities can be involved in the development of propagation and management methods, the likelihood of their having an interest in protecting the wild populations from over-exploitation will be greater. Small-scale cultivation with low economic inputs can be a response to declining local stocks, generating income and supplying regional markets. Besides poverty and the break-down of traditional controls, the major challenges for sustainable wild-collection include: lack of knowledge about sustainable harvest rates and practices, undefined land use rights and lack of legislative and policy guidance.

Sustainable harvesting needs to be recognized as the most important conservation strategy for most wild-harvested species and their habitats, given their current and potential contributions to local economies and their greater value to harvesters over the long term. The basic idea is that non-destructive harvests and local benefits will maintain population, species and ecosystem diversity.

INTRODUCTION
Since time immemorial, people have gathered plant and animal resources for their needs. Among these uses, medicinal plants play a central role, not only as traditional...
medicines used in many cultures, but also as trade commodities, which meet the demand of often distant markets. For the purpose of this paper the term “medicinal and aromatic plant” (MAP) is defined as “plants used not only medicinally sensu strictu but also in the often overlapping fields of condiments, food and cosmetics”.

Demand for a wide variety of wild species is increasing with growth in human needs, numbers and commercial trade. With the increased realization that some wild species are being over-exploited, a number of agencies are recommending that wild species be brought into cultivation systems (Bundesverband der Arzneimittel-Hersteller, 2002; Lambert et al., 1997; WHO, IUCN and WWF, 1993). Cultivation can also have conservation impacts, however, and these need to be better understood.

The relationship between in situ and ex situ conservation of species is an interesting topic with implications for local communities, public and private land owners and managers, entire industries and, of course, wild species. Identifying the conservation benefits and costs of the different production systems for MAP should help guide policies as to whether species conservation should take place in nature or the nursery, or both (Bodeker et al., 1997).

How Many MAP Are Used World-wide?

The number of plant species which have at one time or another been used in some culture for medicinal purposes can only be estimated. An enumeration by the WHO from the late 1970s listed 21,000 medicinal species (Penso, 1980). However, in China alone 4,941 of 26,092 native species are used as drugs in Chinese traditional medicine (Duke and Ayensu, 1985), an astonishing 18.9 percent. If this proportion is calculated for other well-known medicinal floras and then applied to the global total of 422,000 flowering plant species (Bramwell, 2002; Govaert, 2001), it may be extrapolated that the number of plant species used for medicinal purposes is more than 52,000.

How Many MAP Species Are Traded?

It is difficult to assess how many MAP are commercially traded, either on a national or even an international level. The bulk of the plant material is exported from developing countries, while major markets are in the developed countries. An analysis of UNCTAD trade figures for 1981-1998 reflects this almost universal feature of MAP trade (Table 1). Adding the volumes for the five European countries in this list (94,300 tonnes) marks the dominance of Europe as an import region. Germany ranks fourth and third as importer and exporter, respectively, indicating the country’s major role as a transit hub for medicinal plant raw materials world-wide.

Iqbal (1993) estimates that about “4,000 to 6,000 botanicals [= medicinal plants species] are of commercial importance”; another source refers to 5-6,000 “botanicals entering the world market” (Secretariat Convention Biological Diversity, 2001). A thorough investigation of the German medicinal plant trade identified a total of 1,543 MAP being traded or offered on the German market (Lange and Schippmann, 1997). An extension of this survey to Europe as a whole arrived at 2,000 species in trade for medicinal purposes (Lange, 1998). Recognizing the role of Europe as a sink for MAP traded from all regions of the world, it is a qualified guess that the total number of MAP in international trade will be around 2,500 species world-wide.

How Many MAP Are Threatened World-wide?

In many cases, the impact through direct off-take is negatively reinforced by decline owing to changes in land use. Species favoured by extensive agricultural management like Arnica montana in central Europe go into decline, with changes in farming practices towards higher nutrient input on the meadows. This requires habitat management as the key factor in managing species populations (Ellenberger, 1999).

One of the goals of the IUCN Medicinal Plant Specialist Group is to identify the species that have become threatened by non-sustainable harvesting and other factors. The enormity of this task is illustrated by the following estimate. According to Walter and
Gillett (1998), 34,000 species or 8 percent of the world’s flora are threatened with extinction. If this is applied to our earlier estimate that 52,000 plant species are used medicinally, it leads us to estimate that 4,160 MAP species are threatened.

**How Many MAP Are under Cultivation?**

Many medicinal plants, especially the aromatic herbs, are grown in home gardens, some are cultivated as field crops, either in sole cropping or in intercropping systems and rarely as plantation crops (Padua et al., 1999).

Lange and Schippmann (1997) state that of the 1,543 species traded in Germany, only 50-100 species (3-6 percent) are exclusively sourced from cultivation. In Hungary, a country with a long tradition of MAP cultivation, only 40 species are cultivated for commercial production (Bernáth, 1999; Palevitch, 1991). In Europe as a whole, only 130-140 MAP species are cultivated (Pank, 1998; Verlet and Leclercq, 1999). Of more than 400 plants species used for production of medicine by the Indian herbal industry, fewer than 20 species are currently under cultivation in different parts of the country (Uniyal et al., 2000). In China, about 5,000 medicinal plants have been identified and about 1,000 are more commonly used, but only 100-250 species are cultivated (Xiao Pei-Gen, 1991; He Shan-An and Ning Sheng, 1997).

Based on these figures, we assume that the number of MAP species currently in formal cultivation for commercial production does not exceed a few hundred world-wide. Many more MAP species are cultivated, however, on a small-scale in home gardens, either as home remedies or by herbalist or cultivation by local people can take place as enrichment planting. A global survey on the extent of commercial MAP cultivation in terms of species, volumes and values would be highly desirable.

**WILD OR CULTIVATED: WHAT DOES THE MARKET WANT?**

Given the demand for a continuous and uniform supply of medicinal plants and the accelerating depletion of forest resources, increasing the number of medicinal plants species in cultivation would appear to be an important strategy for meeting a growing demand (Uniyal et al., 2000). But why are so few species cultivated and why are some species cultivated and so many others not?

From the perspective of the market, domestication and cultivation provide a number of advantages over wild harvest for production of plant-based medicines:

(i) Wild collected material may be mixed with unwanted, possibly harmful other plant species, whereas cultivation provides reliable botanical identification.

(ii) Wild harvest yields are dependent on many factors that cannot be controlled and the irregularity of supply is a common feature. Cultivation guarantees a steady source of raw material.

(iii) Wholesalers and pharmaceutical companies can agree on volumes and prices over time with the grower.

(iv) The selection and development of genotypes with commercially desirable traits from the wild or managed populations may offer opportunities for the economic development of the medicinal plant species as a crop.

(v) Cultivation allows controlled post-harvest handling and therefore quality controls can be assured.

(vi) Product standards can be adjusted to regulations and consumer preferences. (vii) Cultivated material can be easily certified organic or biodynamic, although certifiers are also presently developing wildcrafting standards (Leaman, 2002; Palevitch, 1991; Pierce et al., 2002; Walter, 2002).

However, domestication of the resource through farming is not always technically possible. Many species are difficult to cultivate because of certain biological features or ecological requirements (slow growth rate, special soil requirements, low germination rates, susceptibility to pests, etc.). Economical feasibility is the main rationale for a decision to bring a species into cultivation, but it also is a substantial limitation as long as sufficient volumes of material
can still be obtained at a lower price from wild harvest. Cultivated material will be competing with material harvested from the wild that is supplied onto the market by commercial gatherers who have incurred no input costs for cultivation. Low prices, whether for local use or the international pharmaceutical trade, ensure that few species can be marketed at a high enough price to make cultivation profitable (Cunningham, 1994). Domestication of a previously wild collected species not only requires substantial investment of capital (up to 200,000 US$; Plescher, pers. commun.), but also several years of investigations (e.g. 12 years for *Alchemilla alpina*; Schneider et al., 1999).

On a time scale of sometimes many decades, the transition from wild harvesting to possible cultivation goes through various phases (Fig. 1):

(i) Discovery Phase, during which the demand can be met by wild harvest. Harvesting is done for local use or for barter with others.

(ii) Expansion Phase: once it becomes clear that the product is potentially useful and that demand is likely to increase, the plant is harvested for local or regional sale and eventually for international markets. In general, species with naturally low densities are unlikely to become important sources of commercially large quantities.

(iii) Stabilization Phase: the species is unlikely to be attractive to growers unless prices are high enough and wild-harvested resources are scarce enough. However, desirable species may be grown on farmland and planted around settlements.

(iv) Decline Phase: prices increase with scarcity due to transport costs, search time and long-distance trade. Wild populations will have to decline further before cultivation becomes a viable option. Trade is characterized by fluctuations in supplies, often to the extent of disrupting the trade balance. If controls on collection are not strictly enforced, wild populations of slow-growing species will be more seriously eroded before cultivated material is available (Cunningham, 1994; Iqbal, 1993).

(v) Cultivation Phase: formal cultivation systems are developed and instituted. The plants are domesticated and incorporated into agroforestry systems, sometimes for the benefit of small-scale farmers. If international market opportunities exist, commercial plantations are created with substantial investment and genetic selection, cloning, breeding and biotechnology may be applied. More resilient species may recover in their wild populations (Fig. 1).

**WILD OR CULTIVATED: WHAT DO PEOPLE NEED?**

**Health Care Needs**

There is a worldwide trend of increasing demand for many popular, effective species in Europe, North America and Asia, growing between 8-15 percent per year (Grünwald and Büttel, 1996). Rapid urbanization and the importance of herbal medicines in African health care systems stimulated a growing national and regional trade in Africa (Cunningham, 1993). Demand for medicinal plants also reflects distinct cultural preferences. In the USA, for example, only 3 percent of people surveyed had used herbal medicine in the past year (Eisenberg et al., 1993), whereas in Germany, with a strong tradition of medicinal plant use, 31 percent of the over-the-counter products in pharmacies in 2001 were phytopharmaceutical preparations (BAH, 2002).

The level of herbal medicine use in most developing countries is much higher than this. While most traditional medicinal plants are gathered from the wild, these are not static health care systems, and introduced species are commonly adopted into the repertoire of plants used by African or South American herbalists. In many cases, herbal medicines can also be cheaper than western medicines, particularly where access to traditional healers is easier. Demand for traditional medicine continues in the urban environment even if western biomedicine is available (Mander et al., 1997).

**Income Generation**

Wild harvesting of medicinal plants is a chance for the poorest to make at least some cash income. Especially those people who do not have access to farm land at all
depend on gathering MAP to earn at least some money. However, local people generally get a low price for unprocessed plant material. Although income from *Prunus africana* bark sales is an important source of revenue to villagers in Madagascar, in some cases generating >30 percent of village revenue, the price paid to collectors is negligible compared to Madagascan middlemen (Walter and Rakotonirina, 1995). In Mexico, Hersch-Martinez (1995) found that medicinal plant collectors only received an average of 6.17 percent of the medicinal plant consumer price.

Whether fruits, roots, bark or whole plants are involved, the potential yield from wild stocks of many species is frequently over-estimated, particularly if the effects of stochastic events like droughts is taken into account. As a result, commercial harvesting ventures based on wild populations can be characterized by a “boom and bust” situation where initial harvests are followed by declining resource availability.

**Small-scale Cultivation and Home Gardens**

Small-scale cultivation, which requires low economic inputs, can be a response to declining local stocks, generating income and supplying regional markets. This can be a more secure income than from wild harvest which is notoriously inconsistent. For farmers that integrate MAP into agroforestry or small-scale farming systems, these species can provide a diversified and additional source of income to the family. Home gardens are increasingly a focus of medicinal plant propagation and introduction programmes intended to encourage the use of traditional remedies for common ailments by making the plant sources more accessible (Agelet et al., 2000).

**Large-scale Cultivation**

As outlined by Leakey and Izac (1997), large-scale cultivation has a number of socio-economic impacts on rural people: “Commercialization is both necessary and potentially harmful to farmers. It is necessary in that without it the market for products is small and the opportunity does not exist for rural people to generate income. A degree of product domestication is therefore desirable. On the other hand, commercialization is potentially harmful to rural people if it expands to the point that outsiders with capital to invest come in and develop large-scale monocultural plantations for export markets. Rural people may benefit from plantations as a result of available employment and hence off-farm income. However, plantations may also distort market forces to their advantage, for example, by imposing low wages that will restrict the social and economic development of local people. The major beneficiaries of large-scale exports will probably be the country’s elite and, perhaps, the national economy”.

Also, socially disadvantaged groups dependent on gathering MAP for their survival and cash income may not have access to farmland at all and are therefore not able to compete with large-scale production of MAP by well-established farmers (Vantomme in Anon., 2002a). Other limitations to the domestication approach include boom-bust and fickle markets that let farmers down when consumers turn their attention elsewhere (Laird and Pierce, 2002).

**WILD OR CULTIVATED: WHAT DO SPECIES AND ECOSYSTEMS REQUIRE?**

Cultivation of medicinal plants is widely viewed not only as a means for meeting current and future demands for large volume production of plant-based drugs and herbal remedies, but also as a means for relieving harvest pressure on wild populations (FAO, 1995; Lambert et al., 1997; Palevitch, 1991; de Silva, 1997; WHO, IUCN and WWF, 1993).

Booming markets with rapidly rising demands often have devastating effects on wild collected species. A closer look reveals that not all species are affected in the same way by harvesting pressures. The seven forms of rarity described by Rabinovitz (1981) make clear that a species which (i) has a narrow geographic distribution, (ii) is habitat specific, and (iii) has small population sizes everywhere, is more easily over-harvested
than species of any other pattern.

Secondly, the susceptibility or resilience to collection pressure varies among species owing to biological characters such as different growth rates (slow growing vs. fast growing), reproductive systems (vegetative or generative propagation; germination rates; dormance; apomixis) and life forms (annual; perennial; tree).

Species can be distinguished quite well in their susceptibility to over-collection if their life form and the plant parts collected are viewed together (Table 2). Harvesting fruits from a long-lived tree presents a far lower threat to the long-term survival of the species than does collecting seeds from an annual plant. In the latter case, if the seed is gone the plant is gone. In some cases the harvest impacts are more complex, e.g. with slow growing trees which reproduce from seed but only produce few, large fruits (example: *Araucaria araucana*, monkey puzzle tree). This will increase their susceptibility to over-harvest from low to medium or even high. A thorough summary of predictors of resilience or vulnerability to harvesting wild populations is presented by Cunningham (2001).

In summary we can state that species most susceptible to over-harvest are habitat specific, slow growing and destructively harvested for their bark, roots or the whole plant. These species suffer most from harvesting and many of them have been seriously depleted, for example *Prunus africana* in West Africa, *Warburgia salutaris* in southern Africa and *Saussurea costus* in the Himalayas.

For highly threatened medicinal plant species cultivation is a conservation option because the constant drain of material from their populations is much higher than the annual sustained yield. If the demand for these species can be met from cultivated sources the pressure on the wild populations will be relieved. In these cases, the need for strict conservation of remaining populations, improved security of germplasm ex situ and investment in selection and improvement programmes is extremely urgent as the example of Jaborandi (*Pilocarpus jaborandi*) in Brazil shows (Pinheiro, 1997).

However, among the species that can be marketed at a high enough price to make cultivation profitable, only few are in the highest threat categories. Examples for threatened but cultivated species are *Garcinia afzelii*, *Panax quinquefolius*, *Saussurea costus* and *Warburgia salutaris* (Cunningham, 1994). With respect to economic viability many highly endangered MAP do not qualify for cultivation. This group of plants will enter cultivation only with the help of public domestication programmes.

For all other harvested MAP species the priority conservation option is sustainable harvest from wild populations, for a variety of reasons.

Let us imagine that a valuable medicinal plant is exploited by local collectors. A pharmaceutical company has domesticated and begun to cultivate the plant on a commercial scale. When the company no longer needs the wild-harvested material, local harvesters have to abandon the harvest and any incentive the local collectors might have had to protect the wild populations is gone. The domestication of MAP species has an environmental implication in the sense that it reduces the economic incentives for forest dependent people to conserve the ecosystems in which the MAP species occur (Leaman et al., 1997; Vantomme in Anon., 2002a).

If collectors and collecting communities can be involved in the development of propagation and management methods, the likelihood of their having an interest in protecting the wild populations from over-exploitation, particularly if these are understood to be the genetic resource “bank” for the domestic enterprises, will be greater.

Another aspect to consider is the genetic diversity of the species, which is in demand. Long before non-sustainable harvest practices lead to extermination of a whole species, selection of favoured growth forms and concentration on certain harvesting areas, which may hold certain ecotypes will lead to a degradation of genetic diversity of the wild populations. The same is true under domestication: Industry requirements for standardization encourage a narrow genetic range of material in cultivation. Domestication will not achieve conservation of genetic diversity, because a narrow group of high yielding individuals will be selected for planting.
Table 3 indicates the advantages and disadvantages for the three aspects distinguished: “species/ecosystems”, “market” and “people”.

**CHALLENGES OF HARVESTING SUSTAINABLY FROM THE WILD**

Sustainable harvest is an important conservation strategy for most wild-harvested species and their habitats, given their current and potential contributions to local economies and their greater value to harvesters over the long term. The basic idea is that non-destructive harvests and local benefits will maintain population, species and ecosystem diversity.

Besides poverty and the break-down of traditional controls, the major challenges for sustainable wild-collection include: lack of knowledge about sustainable harvest rates and practices, undefined land use rights and lack of legislative and policy guidance.

**Lack of Information on the Wild Resource**

“The most important ingredient required to achieve a truly sustainable form of resource use is information” (Peters, 1994). In reality, resource managers are always confronted with a lack of adequate information about the plants used, their distribution, the genetic diversity of wild populations and relatives and, above all, the annual sustained yield that can be harvested without damaging the populations (Iqbal, 1993). Research on the conservation and sustainable use of medicinal plants and their habitats has fallen far behind the demand for this globally important resource. Each species has unique ecological, socio-economic, health and cultural associations that must be understood. Model research approaches are feasible, model solutions are not.

**Problems of Open Access**

In many cases, access to the resource is open to everybody, rather than a limited access or private ownership. To make a living, commercial medicinal plant gatherers therefore “mine” rather than manage these resources (Cunningham, 1994). Open access schemes to harvestable plant population prevent rational and cautious use and make it difficult to adhere to quotas and closed seasons.

**Lack of Legislative and Policy Support for Wild Harvesting Schemes**

Much production and consumption is at subsistence level and as a consequence the economic importance of these activities is largely under-estimated in government decision making regarding rural development, natural resource management planning and in government budget allocations (Vantomme in Anon., 2002a). Therefore, national legislation and policies mostly fail to provide frameworks for a rational and sustainable use of wild resource.

Opportunities for governments to develop legislation to control and monitor harvest and trade of medicinal plant species and to consider conservation and sustainable use of medicinal plants as a priority in establishing protected areas have been greatly enhanced by two recent developments in international legislation: the addition of medicinal plant species to the CITES and the entry into force of the CBD.

**RECOMMENDATIONS**

1. To overcome significant knowledge deficits, a global MAP cultivation survey should be commissioned by an international organization. Aims are to identify species cultivated, in which countries they are grown, volumes produced and their market values. This survey should also assess public domestication programmes, as well as in-situ and ex-situ conservation efforts for wild populations of species in cultivation (e.g., in protected areas, in genebanks and botanic gardens).

2. Limiting the harvest to a sustainable level requires an effective management system and sound scientific information (Table 4). Sustainable wild harvest management schemes need to be supported by governments and authorities. Management plans need to be installed as a standard pre-requisite for any such harvesting in the wild.
They must include annual harvest quotas and consider seasonal or geographical restrictions and restriction of harvest to particular plant parts or size classes. There is a need to monitor and audit the harvesting process to determine whether it is sustainable.

3. Primary producers need help to improve returns from sustainable harvesting of MAP. Community based small scale cultivation enterprises need to be strengthened to enable them to compete with large-scale high-tech cultivation.

4. Secure ex situ field gene banks need to be developed, particularly for habitat specific, slow-growing species with high susceptibility of being over-harvested.

5. Medicinal plant domestication programmes need to be expanded, taking fuller advantage of the genetic and chemical diversity within species over wide geographical areas.

6. Capacity to assess and monitor the conservation status of MAP and to manage harvest within the limits of sustainability is extremely limited worldwide and needs to be developed through training courses and curriculum development in ethnobotany and applied ecology. Research to investigate the sustainability of production systems is lacking and needs to be stimulated for a better understanding of the biological dynamics of the resource in the wild and in domestication.

7. Management planning has to take the diversity of tenure systems which apply to medicinal plants into account to a far greater degree. Clarification of user rights over the resource and access to it, particularly where it is considered common property, needs to be recognized as a crucial factor enabling or preventing a sustainable harvest from wild populations.

8. Eco-labelling and other social and economic incentives to strengthen market credibility and competitiveness of biodiversity-friendly products need to be promoted. The efforts of certifiers to develop certification standards for wild harvested plant material need to be supported as well as the approaches of industry to set up self-binding product quality standards. The private sector should be encouraged to consider local livelihoods and biodiversity when setting up ethical and environmental standards.

9. The Good Harvesting/Sourcing Practice (GHP/GSP) under preparation for medicinal plants by EMEA, WHO and other initiatives cover ecological aspects to some degree, but need to be more clearly focussed on this aspect.

10. Conservation of medicinal plants currently lacks priority in policy and law. There are opportunities to change this within the implementation of legal instruments such as the CBD and CITES. Government policies and legislation need to be adapted and implemented to recognize the value of and need for sustainable wild harvesting management regimes, to implement national and/or regional permit systems and make medicinal plant conservation a priority for national health and economic policy.

11. The Global Environment Facility (GEF) needs to consider medicinal plant conservation as a programme priority worthy of funding.

12. Medicinal plants warrant priority in national efforts to implement the Global Strategy for Plant Conservation of the CBD.

13. Local communities can take more responsibility for sustainable harvest of medicinal plants only if they have the choices afforded by adequate income, control over the resource and the knowledge and skills required. On the issue of intellectual property rights it needs to be elaborated how the country, the local user or other entity can be adequately compensated for use of the resource by outsiders.

Literature Cited


### Tables


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<td><strong>Total</strong></td>
<td><strong>281,550</strong></td>
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Table 2. Susceptibility of species to overcollection as a function of life form and plant parts used.

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Table 3. 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 ...
  - 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
- but ...
  - 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 pre-cautionary 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

- cultivate because ...
  - it relieves harvesting pressure on very rare and slow-growing species which are most susceptible to threat
- but ...
  - devalues 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
Table 3. (Continued) Wild harvesting versus cultivation of medicinal and aromatic plants: A summary of advantages and disadvantages.

<table>
<thead>
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<th>The market demands …</th>
<th>cultivated material because …</th>
</tr>
</thead>
<tbody>
<tr>
<td>wild harvested plants because …</td>
<td>it guarantees continuing supply of raw material</td>
</tr>
<tr>
<td>it is cheaper since it does not require infrastructure and investment</td>
<td>it makes reliable botanical identification possible</td>
</tr>
<tr>
<td>many species are only required in small quantities that do not make cultivation economically viable</td>
<td>genotypes can be standardized or improved</td>
</tr>
<tr>
<td>for some plant parts extra-large cultivation areas are required (e.g. Arnica production for flowers)</td>
<td>quality standards are easy to maintain</td>
</tr>
<tr>
<td>successful cultivation techniques do not exist, e.g. for slow growing, habitat specific taxa</td>
<td>controlled post-harvest handling is possible</td>
</tr>
<tr>
<td>no pesticides are used</td>
<td>production volume and price can be agreed for longer periods</td>
</tr>
<tr>
<td>it is often believed that wild plants are more powerful</td>
<td>resource price is relatively stable over time</td>
</tr>
<tr>
<td>but …</td>
<td>certification as organic production is possible</td>
</tr>
<tr>
<td>­there is a risk of adulterations</td>
<td>it is in general more expensive than wild harvest</td>
</tr>
<tr>
<td>­there is a risk of contaminations through non-hygienic harvest or post-harvest conditions</td>
<td>it needs substantial investment before and during production</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>From a perspective of the people it is better to …</th>
<th>cultivate because …</th>
</tr>
</thead>
<tbody>
<tr>
<td>wild harvest because …</td>
<td>it secures steady supply of herbal medicines (home gardens)</td>
</tr>
<tr>
<td>it provides access to cash income without prior investment</td>
<td>it provides in-country value-adding</td>
</tr>
<tr>
<td>it provides herbal medicines for health care needs</td>
<td>but …</td>
</tr>
<tr>
<td>it maintains the resources for rural populations on a long-term basis (if done sustainably)</td>
<td>capital investment for small farmers is high</td>
</tr>
<tr>
<td>but …</td>
<td>competition from large scale production puts pressure on small farmers and on wild harvesters</td>
</tr>
<tr>
<td>unclear land rights create ownership problems</td>
<td>benefits are made else-where and traditional resource users have no benefit return (IPR)</td>
</tr>
<tr>
<td>this income and health care resource is becoming scarce through over-harvesting</td>
<td></td>
</tr>
</tbody>
</table>

- resource inventory of population abundance and distribution
- assessment of regional and global threat based on all available knowledge and expertise
- biological studies (growth and regeneration rates, pollination system, seed dispersal, potential for confusion with similar species, etc.) and assessment of harvest impact on viability of individuals
- assessment of annual sustained yield
- review of local knowledge and harvest practices
- review of harvest and trade levels in the past and evaluation of market trends
- revision of national regulations for the utilization in source country
- assessment of tenure and access
- design and implementation of management scheme: annual harvesting quota, seasonal or regional restriction and on certain plant parts or size classes, domestication programme
- installation of continuing monitoring and re-evaluation (adaptive management)

Figures

Fig. 1. Transition phases from wild harvesting to cultivation. After wild resources decline with over-harvesting, raw material prices increase and cultivation becomes economically feasible; more resilient species can recover (after Homma, 1992 and Cunningham, 2001). The possibility of substitution by synthetic substances is not discussed in this figure.