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Underutilized crops: trends, challenges and opportunities in the 21st Century

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Introduction

Plant biodiversity represents the primary source for food, feed, shelter, medicines and many other products and means that make life on Earth possible and enjoyable (WCMC, 1992; UNEP 1995). The number of plant species used by humans around the world (Table 1) is only one third of the number of species which generations of diverse cultures around the world have drawn upon to develop crops that would meet specific needs. The centres of diversification of most common cultivated species are known today (Zeven and de Wet, 1982), but for many other species of local importance, the knowledge on the distribution of their genetic diversity and use patterns are still largely limited. Increased reliance on major food crops has been accompanied by a shrinking of the food basket which humankind has been relying upon for generations (Prescott-Allen and Prescott-Allen, 1990). This *nutritional paradox* (Ogle and Grivetti, 1995) has its roots in the agricultural “simplification”, a process that favoured some crops instead of others on the basis of their comparative advantages for growing in a wider range of habitats, their simple cultivation requirements, easier processing and storability, nutritional properties, taste, etc.

Though the simplification process lowered food quality, it increased the chances of successful harvests, which in turn allowed survival through narrow but abundance sustenance (Collins and Hawtin, 1999). However, the shrinking of agricultural biodiversity has reduced both the intra and interspecific diversity of crops, increasing the level of vulnerability among users, particularly the poorer sections, for whom diversity in crops is a necessity for survival rather than a choice. Extensive literature documents the dramatic effects of genetic erosion in staple crops (Fowler and Mooney, 1990 and references therein), comparably less has been published however on the effects of the narrowing of the food basket leading to reduced quality of life.

A change in attitude is noticed over the last 5-10 years among policy makers and the public with regard to the quality of life as related to the quality of food as well as diverse sources of food. Vitamins and other micronutrients are for instance being searched in crops and plant species with greater emphasis than in the past in recognition of their role in combating diet imbalances. Although ‘hidden hunger’ affects mainly developing countries, particularly children and older people (FAO, 1997), it is increasingly being recorded also among the more vulnerable social groups in developed nations.

If the 20th Century witnessed the undertaking of systematic collecting to rescue the genetic resources of staple crops (Pistorius, 1997), the 21st Century has started with the awareness on the need to rescue and improve the use of those crops left aside by research, technology, marketing systems as well as conservation efforts. These underutilized crops (referred to also by other terms such as minor, orphan, neglected, underutilized, underexploited, underdeveloped, lost, new, novel, promising, alternative, local, traditional, niche crops) have been included in world-wide plans of action after having successfully raised the interest of

decision makers. Leading international research organisations such as the Consultative Group on International Agricultural Research (CGIAR), are also among those taking a keen interest in strengthening the work on these species (Swaminathan, 1999).

This global "opening" towards underutilized species is the result of a gradual change of attitude towards biodiversity and plant genetic resources by many countries. Instrumental in this awareness raising process have been the 1992 Convention on Biological Diversity and the FAO IV International Technical Conference on Plant Genetic Resources for Food and Agriculture held in Germany in 1996 (cfr. Activity 12: "Promoting development and commercialization of underutilized crops and species") (UNEP 1992, FAO 1996a). The Global Forum on Agricultural Research (GFAR) in 1999 also emphasized the role of underutilized species in raising income of the rural poor (Frison *et al.*, 2000).

This paper addresses some aspects related to improving the conservation and use of neglected and underutilized crops through the experiences of the International Plant Genetic Resources Institute (IPGRI) (Padulosi *et al.*, 1999) and the International Center for Underutilized Crops (ICUC) (Smith, 1997), both of which have been directly involved with these species since their establishment.

Underutilized crops: is there an agreement on what they are?

Perhaps no agriculture term has raised more discussions among workers than the word underutilized! Underutilized is commonly applied to refer to species whose potential has not been fully realized. The term itself does not provide any information as to geographical (**underutilized where?**), social (**underutilized by whom?**) and economic (**underutilized to what degree?**) implications. It is thus not surprising that whenever underutilized species are being addressed in national or international fora there is inevitably a call for a clarification over the exact meaning of such a term. The following are some examples to explain the source of confusion on this term. With regard to the **geographical distribution**, often a species could be underutilized in some regions but not in others. The cowpea (*Vigna unguiculata*) is, for instance, a staple crop for millions of people in sub Sahara Africa, but the same is considered as an underutilized crop in some Mediterranean countries where it was once widely used and now is grown in some restricted areas (Padulosi *et al.*, 1987). Similarly chickpea (*Cicer arietinum*) considered by many Italian scientists an underutilized species in their country is a main pulse crop in Syria and other countries in West Asia. Regarding the **socio economic implication** of the term, many species represent an important component of the daily diet of millions of peoples (such as leafy vegetables in Sub Sahara Africa) (Guarino, 1997) but their poor marketing conditions make them largely underutilized in economic terms. With regard to the **time factor**, the degree of underuse of a crop may be subject to a sudden improvement due to dynamic marketing systems present in some countries while the same crop may continue to be poorly marketed and managed by researchers in others. This is the case, for instance, of the vegetable rocket (collective name for the species *Eruca sativa*, *Diplotaxis tenuifolia* and *D. muralis*). Rocket has become a highly priced vegetable in Europe through innovative cultivation and commercial practices (Pimpini and Enzo, 1997), while it is among the cheapest vegetables in Egypt and a rich source of micronutrients for the poorer classes (Mohamedien, 1995). The importance of this crop for millions of people in Egypt has however not been enough to convince local policy makers to give it more attention that it deserves. A similar case is that of hulled wheats, a collective name for *Triticum monococcum*, *T. dicoccum* and *T. spelta*. This is an important speciality crop in Italy and other European countries where *ex situ* and *in situ* conservation are being supported along with considerable research efforts (Padulosi *et al.*, 1996b). However, it is a typical "*life support*" crop in remote areas of Turkey with the very last relic populations of *T. monococcum* being cultivated in poor subsistence farming systems (Karagöz, 1996).

Underutilized crops are being often presented as ‘**new crops**’ (Vietmeyer, 1990) for the fact that commercial companies/researchers are only recently working on them. In reality, local populations over generations have used these species. Yet the loss of local knowledge and thus the increasing ignorance of new generations on the traditional uses of these crops also contribute to portraying such a misleading image. Of course, a crop can be completely new to an area simply because it has been introduced there recently from a distant country as in the case of the kiwi fruit, unknown outside China or New Zealand till recently (Ferguson, 1999), and the of *Annona* fruits (custard apple) introduced into Lebanon in the recent past.

Because of recurrent confusion among workers on the distinction between the term underutilized and neglected, it is worthwhile reporting here IPGRI’s definitions (Eyzaguirre *et al.*, 1999) for these two categories of crops:

Many **underutilized crops** were once more widely grown but are today falling into disuse for a variety of agronomic, genetic, economic and cultural factors. Farmers and consumers are using these crops less because they are in some way not competitive with other crop species in the same agricultural environment. The general decline of these crops may erode the genetic base and preventing the use of distinctive useful traits in crop adaptation and improvement.

Neglected crops are those grown primarily in their centres of origin or centres of diversity by traditional farmers, where they are still important for the subsistence of local communities. Some species may be globally distributed, but tend to occupy special niches in the local ecology and in production and consumption systems. While these crops continue to be maintained by socio-cultural preferences and use practices, they remain inadequately characterized and neglected by research and conservation.

The understanding of the causes behind the low level of use and/or neglect of a crop is however what is ultimately needed in order to design an appropriate strategy to address its improvement. In the rest of this paper, in the interests of readability, we use underutilized in its “broad sense” to refer to both underutilized and neglected species, unless specified in the text.

Challenges in the promotion of underutilized species

United commodities stand! Divided new crops fail! This remark made in a paper addressing the prospects of new crops in the USA at the 1990 International Conference on Advances in New Crops (Duke, 1990) captures the feeling of many workers engaged in the promotion of underutilized crops. Though it is true that the funding for addressing research and hence improvement of these species around the world is still extremely small, it should be also noted that other important factors, similarly determinant in the promotion process, should not be under-estimated. For example, during a participatory conference organized by IPGRI in 1998 in Aleppo, Syria, on “Priority Setting for Underutilized and Neglected Plant Species of the Mediterranean region” (Padulosi, 1999a), 10 major categories of constraints were identified as most relevant for the promotion of underutilized species. As Table 2 shows, some of the constraints were not linked to lack of funds as their solution lies in the strategic mobilization of existing resources to address the real problems hampering the full utilization of the species.

Most challenges in the promotion of underutilized species are now well understood and appreciated and have been addressed in numerous works (Sankary, 1977; Hawkes, 1987; Lazaroff, 1989; von Maydell, 1989; De Groot and Haq, 1995; FAO, 1996b; Bhag Mal *et al.*, 1997; Macted *et al.*, 1997; Monti, 1997; Heywood, 1999; Padulosi, 1999a). However, an

increasingly key issue in improving the use of underutilized species is the globalisation of the agricultural market. This is part of a much wider phenomenon that is changing dramatically our life and includes urbanization, loss of small commercial activities replaced by large enterprises, the homogenization of local cultures as a result of the spreading of few models and cultures and improved communication. With specific reference to agriculture, globalisation is bringing about a further specialization in favour of a few crops that might best serve "*Global Village*". Obviously, this trend will lead to much narrower agricultural basket, estimated to hold only some 150 widely commercialized crops (Prescott-Allen & Prescott-Allen 1990), in favour of some commodities which will enter newer areas and displacing local ones.

For many supporters of the globalisation process, this is the great opportunity for economic growth, but for many more it is a dealer of illusions, carrying prospects of a wealthy life that cannot be met and hiding the high cost to pay in terms of loss of sustainability, traditions, culture and local economies. Without entering the debate over the issue of globalisation, we would like to respond to the question that is raised in many occasions by those who see no future for underutilized crops in the *Global Village*: why should underutilized species be promoted in an increased global world if these are characterized by regional, national or local importance? The answer is very simple: securing the resource base of underutilized species, particularly in developing countries, is crucial to maintain the "safety net" made of diversified food and natural products that has provided options to address food needs in a sustainable way (Eyzaguirre *et al.*, 1999). Diversification in agricultural systems is indeed an important asset for those fragile social groups who may never be able to afford certain commodities and to whom the more diversified is the portfolio the greater is their self-sustainability and self-reliance in difficult areas where they live, often characterized by conditions not suitable for the cultivation of improved varieties of commodity crops.

Generally speaking, plants are a fundamental component of the natural resource available to the poor and the role played by underutilized species is indeed central to reducing poverty and empowering the poor so as to allow poor rural communities to pursue resources-based rather than commodity-based development (Burgess, 1994; Blench, 1997). But the people who benefit from underutilized species in a globalized world are not just for the poor. The benefits in terms of more balanced diets, diversified income to farmers as well as related sectors of the society, better maintenance of agroecosystems and greater use of marginal lands along with enhanced preservation of cultural identity (Padulosi, 1999b and references therein) can be shared by all the humankind.

Choice of the species

In developing work on underutilized crops, research and development agencies face substantial problems. The most obvious is that of deciding which crops to work on. Picking the right species from a broad group of potential candidates is a necessary step to make the best use of limited (as always the case in this area) resources. Selecting species that can be used as a "case study" may be possible and will also help to build up a knowledge base in the promotion process and thus enhance future efforts on other underutilized crops.

The selection of the species should be based on the analyses of its contribution to meet the goal that has been set out. The ultimate goal may vary however among stakeholders. For organisations like IPGRI and ICUC, the goal in the work on underutilized species include the improvement of food security; enhance nutritional balances, sustainability in agriculture and alleviation of poverty through income generation. The contribution of the species will be therefore assessed against their present contribution to meet these goals as well their potential contribution to be realized after our intervention. Needless to say that the longer is the list of criteria we set out for the selection, the more difficult the selection process will be.

The 12 criteria recommended for the selection of underutilized food producing trees developed by von Maydell (1989) given in Table 3 would be certainly useful to guide the process, but it is unlikely that we would find a single species that would meet all of them.

The complexity on the selection process is made even more challenging by the limited and poor quality of information available on these species. Ultimately, the key factor for a successful selection is the involvement of direct users in the selection process. Adopting this approach will ensure that the species that is favoured by the ultimate recipient of our efforts, farmers, rural and forest dwellers. Such an approach was followed by IPGRI in its project on leafy vegetables supported by the Dutch Government, which focused on leafy vegetables in 5 sub-Saharan African countries. During the first phase of this project, the surveys carried out together with farmers have yielded enough elements to select a number of priority species (Table 4) that can be used in the second phase of the project, which will focus on crop and market improvement.

The views of farmers and other stakeholders (universities, research centres, private groups, etc.) should be seen as dynamic and subject to shift in emphasis with regard to type of crop depending on changes in opportunities and needs. Today, for instance, an increased interest is recorded among national and international research organisations towards medicinal and aromatic species in view of their role in improving the health of poor and their contribution to combat poverty through income generation (Leaman *et al.*, 1999). Attention to underutilized species may also originate from considerations that are not directly related to food security or poverty alleviation, but to the need to safeguard artistic, landscape and cultural values of these species. This is for instance the objective of the international workshop organised by the Italian National Research Council (CNR) in 1997 in Naples (Monti, 1997).

Securing the resource base of underutilized species

Securing the resource base of underutilized species is a key component of the whole promotion process and is central to IPGRI's concerns. The maintenance of genetic diversity through a complementary *ex situ* and *in situ* approach can ensure that all users, including farmers and breeders will have the access to material to carry out their activities. In order to understand the relationship between the conservation and the other elements in the promotion process, it is useful to see how conservation fits within the whole promotion process. Table 5 lists some of the major problem areas that can be identified for underutilized crops and the ways in which they might be addressed. Access to appropriate plant material can be an important factor in addressing most of the areas identified and particularly relevant to tackle the first two, i.e. securing genetic resources and documenting and using traditional knowledge.

The provision of genetic diversity to allow crop improvement has been a central element of the green revolution (CGIAR, 1994). One of the most important elements of successful work on underutilized crops will be the full recognition of how important is work to safeguard their genetic diversity and to ensure its fullest use. The establishment of germplasm collections for underutilized species has been advocated in the Global Plan of Action of FAO (FAO, 1996a) and is one key element of the promotion process pursued by several other international organizations, including IPGRI and ICUC.

However, the evidence suggests that *ex situ* conservation of many underutilized species is highly inadequate. More than 6 million accessions of plant genetic resources for food and agriculture are conserved today in some 1,300 germplasm collections around the world. Although the number of these collections is an impressive one, an analysis of the type of crop plants they contain is disappointing: about 80 % of these belong to major crops and their close relatives. The remaining 20% are other crops, including underutilized crops, which

are very poorly represented (less than 8 accessions per species) (Padulosi, 1999b). Figure 1 shows in details the statistics related to such a situation.

We must concede that there will never be sufficient resources for large scale formal conservation activities. Hence, in order to achieve a sustainability of the process, conservation and use must be closely linked to each other, thus 'conservation through use' becomes important. Most of the conservation will in practice be through the continued use of these species in production systems. For example, in the case of the African leafy vegetables, the understanding of the users' needs (species with larger leaf area per plant and delayed flowering) is crucial to strengthen the on farm maintenance of those crops. Another crucial strategic aspect in the sustainable promotion of underutilized species is adding value to existing crops. *Cleome gynandra*, for instance, a leafy vegetable with insect repellent properties can be very valuable in intercropping systems. Interestingly, many underutilized species indeed, have multiple uses and do not belong to any one specific category of crops (food, medicinal, ornamental, etc.). This means that high levels of diversity will be needed in production systems to meet different production environments, user needs and uses. The material in production provides one element of an integrated conservation strategy where the *ex situ* collections remain small and are developed through sharper analyses of crop distribution patterns, genetic diversity, etc. On the other hand greater efforts for the gathering of information on the distribution, use and traditional knowledge on these crops will need to be pursued as such data will be very valuable to improve future access to material by researchers and other users. Securing material in production as well as the information on material that is already in production therefore becomes an important element in the strategy for conserving the diversity of underutilized species.

Since the needs and use are often primarily local, so the actions will be local and community based. Local mechanisms that support the deployment of useful diversity will need to be strengthened. For example, house-hold "filières", largely run by women, built in rural and forest areas typically around multiple uses of the same crop, should be improved or established anew if no longer present. These chains, linking farmers up to final end-users, play a critical role in securing revenues to rural communities and thus fuelling the very mechanism that will maintain the diversity of these species in the field (see also next chapter on the filiere issue).

Securing and strengthening the work on underutilized crops

Developing and monitoring the work

Efforts so far have been directed to raise the awareness on the need to work on underutilized species and to start redressing their status of neglect. An area that has not been investigated yet is the analysis of when a *species will evolve* from its status of underuse and neglect to *become a well utilized crop*. This is a very relevant point if we want to make sure our efforts will lead ultimately to the "full promotion stage" beyond which the crop will no longer be considered underutilized. It is also very relevant to ensure that efforts to promote a specific crop have the desired effects with respect to the interests and needs of poor farmers, the maintenance of diversity and strengthening sustainability of production. It has to be recognized that some efforts on underutilized crops (e.g. kiwi, which was one of them before it became an important commodity) have done none of these things.

Below are some of the issues that we should consider to develop a monitoring system for assessing the impact of our promotion process:

Conservation aspects

1. How many accessions should be conserved (*in situ* and *ex situ*) to safeguard of the representative genetic diversity of these species and to provide at the same time the variability needed by breeders and users in general?
2. Given the new opportunities brought about by the gene transfer, how broad should be our efforts in the conservation of the gene pool of the species. Should we include the tertiary gene pool in our collecting efforts?
3. What should be the minimum level of knowledge on the ecogeographical distribution of the taxa and its genetic erosion status?
4. How much local knowledge should be safeguarded?

Utilisation aspects

1. What would be the level at which we would consider the economy of the species self-sustainable?
2. What is the research threshold, that is the minimum amount of research addressing the economic development of the crop, beyond which we would consider the species "properly addressed"?
3. What would be the minimum information needed on nutritional aspects, processing aspects required for successful industrial applications?

Agronomic aspects

1. What should be the minimum know-how required for enabling a proper cultivation of the species?
2. What should be the basic information required for understanding the multiplication method and regeneration capacity of the species?
3. What should be the minimum level of information on pests, diseases and other cultivation-related problems?

Policy-Legal aspects

1. What should be a basic policy framework to enable the proper deployment of the species among the farmers?
2. What should be the minimum level of policy attention required to ensure a sustainable use of these resources (particularly for wild species)?

The need for information

The availability of information has been always a major constraint in the promotion of underutilized species. This will continue to be so, particularly with regard to the monitoring of the points raised above. For this reason, it is important to stress the need for a change in attitude while reporting the agricultural statistics at both national and international levels. The agricultural statistics year book of FAO, could for instance, also be broadened in its scope by using less general figures (e.g. root and tuber crops) and by including crops that are not commodities but that are being marketed and for which information may already be available at national level. The possibility to access these data for guiding workers at local level should be also addressed. Opportunities for strengthening informatics capacities, for instance one computer per village managed by local extension officers, should not be seen as far fetched.

Improving the availability of information on underutilized crops is one of the most important areas that demand our immediate attention. At the formal level, individual studies on underutilized crops continue to need support to ensure their publication. Further studies that bring together the sparse and often inaccessible literature are also needed. At local level, there is a need to gather and document information that is maintained within farming communities. The recognition of the value of this by researchers and scientists can often act as a powerful stimulus to improving a community's own valuation of the knowledge.

The importance of partnerships

The work on underutilized species is perhaps the most challenging endeavour in the history of plant genetic resources since the early 1970s, a period that witnessed a world race to rescue of landraces of major crops (Pistorius, 1997). The green revolution was made possible by the use of that collected diversity but also thanks to the strengthening of national and international research to address the improvement of these major crops. Today, underutilized species will perhaps never command such a major undertaking as major crops did and they would thus need a different approach for their promotion.

Such an approach would have as its most strategic part, the so called “filiere”. Filiere is a French word used to define the link between all stakeholders and activities starting from the collection, use enhancement, policy definition to marketing and commercialisation. Such a chain of actors, which is needed at local, regional, national and international level, will allow to cover research aspects but also marketing and policy issues usually dealt with in isolated fashion. The filiere concept can be considered an evolution of Networking concept for plant genetic resources based on **more efficient partnership and participatory approaches**. The filiere would thus bring about greater participation of local actors to ensure the addressing of local needs properly. It would also ensure the wider representation and participation of stakeholders of food processing and marketing sector as well policy makers who have traditionally been left aside from PGR activities (Padulosi, 1999c).

Such a partnership for underutilized species in many cases will have to be re-invented and this should not discourage partners. The filiere approach will build up a more coherent system to meet the multiplicity of challenges in the promotion of underutilized species. Although, the filiere will be made up of particularly by local, regional and national players, there will be a role for international organizations to ensure that lessons learnt in one region can benefit also other regions. The strengthening of the links among international stakeholders involved in the promotion of underutilized species is indeed strategic to allow best use of existing capacities and promote synergism across regions.

Underutilized species constitute a category defined by their social value and status. For this reason people and farmers play an important role in reversing their decline in use and arresting their genetic erosion. Farmers and forest dwellers are the source of information for revealing the potentials of these species, their distribution and local use. Participatory research should be therefore actively pursued among stakeholders, particularly in the following areas:

- constraint analyses (“production to consumption”) and development of strategic work plans for enhancing seed/germplasm selection and supply, production, processing, commercialisation, marketing (*greater cooperation between private sector and extension workers*);
- characterisation and evaluation work using formal descriptors and farmers’ criteria (*closer cooperation between informal associations /NGOs and international and national research organisations*)
- development / strengthening the seed supply systems, both formal and informal (*closer participation of farmers in government-lead efforts*)
- participatory plant breeding and selection activities (*bridging the gap between farmers’ needs and breeders’ objectives*)

Research issues and opportunities

Neglected and underutilized crops are essential to the livelihoods of millions of poor farmers throughout the world. As noted above, they are part of the (threatened) biological assets of the rural poor. In identifying research and development issues, which should be addressed, it is essential to approach the problem from this perspective. Trying to convert an underutilized crop into some modern high value commodity may not only be inappropriate to a community's real needs and concerns, it may be actually counter-productive. Similarly it does nothing to address the problems for the remaining hundreds of underutilized crops.

One key strategic element involves the deliberate attempt to explore how conservation and use can be combined to secure the resource base of such crops. The approaches may differ, depending on whether the crop is seed propagated or clonally propagated, annual or perennial, outbreeding or self-pollinated. However the basic questions remain the same. What is the smallest size of *ex situ* collection that can cover substantial amounts of diversity and how can it be most economically maintained? How much diversity will remain in production systems and how can this be monitored? How can resources be secured through linkages and collaborations, involving producers, consumers, the formal and informal sectors, to ensure that both conservation through use and conservation for use can be sustained?

New technologies (e.g. molecular genetics and GIS) will certainly play their part in the process of developing conservation and use strategies. There are already a number of examples which show how useful they can be (Young *et al.* 1999), but often only in small research scale activities and need scaling up. Perhaps there needs to be some deliberate determination of the way in which these powerful tools can be best used for such crops.

As implied above, there is also much work to be done on the development of sustainable linkages between organizations, farmers and consumers. It will always be unlikely that any one organization will have the resources to support work on the scale needed for the individual underutilized crops. Thus the interest in networks and filieres and a major challenge is how to make these networks perform and to make them sustainable.

Strengthened community involvement in the management of underutilized crops and a deliberate attention to resourcing their needs for new materials (and securing access to existing ones) will provide a basis for some more work on key production issues. The first of these is obviously that of the development of improved materials. Participatory plant breeding approaches may not only be an important element of the work on these crops; it may be the only feasible approach to obtaining improved materials. Similarly, participatory approaches may be essential to resolving other production and marketing constraints.

Ultimately, we have to recognize that underutilized crops present their own range of problems and opportunities. These are important to many farmers in ways that are complementary to and are different from their concerns for the major crops. Attempting to copy large crop solutions across to these species will help neither in the improved conservation and use of the crops nor the interests of the farmers who grow them. Developing an agenda specific to the crops must be recognized as an important and continuing need.

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Table 1. Estimates of number of plant species used around the world.**Part A: Global assessments**

Author	Year	No. of species	Uses
Heywood	1991	100,000	Used plants
Paroda and Mal	1993	80,000	Explored by humans since dawn of civilization
Myers	1983	75,000	Edible
Wilson	1992	30,000	Edible
Kunkel	1984	12,650	Edible
Uphof	1968	9,500	Economic uses
Wilson	1992	7,000	Source of food (wild/cultivated)
Terrell <i>et al.</i>	1977	3,000	Vascular species of economic importance
Zeven and de Wet	1982	2,489	Cultivated species excluding ornamentals, timber crops, and lower plants
Rehm	1994	2,454	Agronomic plants

Part B: Regional or crop oriented assessments

Country/Region	Reference	Year	No. spp.	Type of species w= wild; c= cultivated; wd =weedy
World-wide				
--	Simons	1996	2,500	Tree agroforestry species
--	Wickens	1995	542	Edible nuts
--	Vietmeyer	1990	1,500	Edible nuts (w/c)
--	Heywood	1999	25,000	Medicinal
--	Vietmeyer	1990	60,000	Medicinal (w/c)
--	Vietmeyer	1990	2,000	Pesticide (w/c)
--	Vietmeyer	1990	3,000	Contraceptive (w/c)
Africa				
--	Jardin	1967	1,410	Indigenous wild species: 60 grass seeds, 50 legumes, 60 oil seeds, >550 fruits/nuts, >600 spices
West Africa	Burkill	1985	>4,600	Useful
Botswana	Campbell	1986	150	Edible
Ghana	Abbiw	1990	2,500	Useful
Kenya	Juma	1989	>100	Vegetables and fruits (w/c) (Bungoma District, West Kenya)
Kenya	Maundu <i>et al.</i>	1999	800	Indigenous food
Morocco	Hmamouchi	1999	340	Medicinal (c/w)

o				
Sahara	Harlan	1989	60	Edible grasses (w)
Sahel	Becker	1984	800	Edible
Southern Africa	Heywood	1999	900	Medicinal
Swaziland	Ogle and Grivetti	1985	> 200	Edible (w)
Zambia & S. Zaire	Malaisse and Parent	1985	184	Edible vegetables (w)
Americas				
--	Brucher	1989	170	Economic
Mexico	Alvarez-Buylla <i>et al.</i>	1989	338	Home gardens (w/c)
Canada	Bates	1985	30,000	Nursery trade
USA	Yarnell	1964	130	Edible of the Upper Great lakes region
USA	Yarnell	1964	400	Useful (excluded food) of the Upper Great lakes region
Peru	Padoch <i>et al.</i>	1991	168	Useful in home gardens (w)
Europe				
Portugal	Anonymou s	1996	500	Medicinal and aromatic
Ukraine	WCMC	1992	300	Medicinal and aromatic
Russia	Chikov	1973	2,000	Potentially useful in medicine
Asia				
Indian Himalaya	Samant and Dhar	1997	675	Edible (w)
South East	Jansen <i>et al.</i>	1991	1462	Timber trees
South East	Jansen <i>et al.</i>	1991	285	Feed species
South East	Jansen <i>et al.</i>	1991	228	Vegetables
South East	Jansen <i>et al.</i>	1991	110	Spices and condiments
South East	Jansen <i>et al.</i>	1991	72	Dyeing plants
South East	Heywood	1999	6,000	Used so far
India	Arora and Nayar	1984	320	Economically important (w/wd)
India	de Padua <i>et al.</i>	1999	1100-1500	Medicinal
India (Uttar Pradesh)	Heywood	1999	480	Edible (w)

Pakistan	de Padua <i>et al.</i>	1999	300	Medicinal
Sri Lanka	de Padua <i>et al.</i>	1999	550	Medicinal (flowering plants)
New Guinea	de Padua <i>et al.</i>	1999	>600	Medicinal
Bangladesh	Ashraf <i>et al.</i>	1999	500	Medicinal
Vietnam	de Padua <i>et al.</i>	1999	1,800	Medicinal
Indonesia	de Padua <i>et al.</i>	1999	1,000	Medicinal
Philippines	de Padua <i>et al.</i>	1999	850	Medicinal (w -used in "jamus")
Philippines	Madulid	1979	200	Fruits (trees-shrubs)
India	Paroda and Mal	1989	536	Economic (w/wd/c)
India	Arora and Pandey	1996	1,000	Edible (w)
Malaysia	Saw <i>et al.</i>	1991	820	Edible fruit trees (diameter > 1 cm)
Mediterranean region				
--	Bianco	1989	137	Vegetables indigenous
--	Bianco	1992	50	Vegetables indigenous
Italy	Hammer <i>et al.</i>	1992	522	Cultivated (indigenous and introduced)
Italy	Corbetta	1991	90	Edible (salad, condiment, soups, etc.)
Jordan	Al-Eiswi and Takruri	1989	142	Edible
Tropics				
--	Martin <i>et al.</i>	1987	2,800	Edible fruits
--	Vietmeyer	1990	3,000	Fruits (w/c)
--	Heywood	1999	18,000-25,000	Used so far

Table 2. Assessment of constraints in the promotion of underutilized species in the Mediterranean region (highest number correspond to a greater constraint).

CONSTRAINTS	MAP	Forest Trees	Fruit trees & Nuts	Vegetables	Forages Browns	Industrial	Ornamental	Legumes	Cereals
Low competitiveness	3	3	3	3	3	3	3	3	3
Lack of knowledge on uses	3	3	3	3	3	3	3	3	3
Lack of research on GD assessment and use	3	3	3	3	3	3	3	2	2
Policy & Legislation	3	3	3	3	3	3	1	1	1
Loss of traditional knowledge	3	3	2	3	2	2	2	1	1
Lack of market/poor commercialisation	3	2	2	2	3	3	3	1	1
Low income	2	3	2	2	3	3	1	2	2
Lack of propagation techniques	3	3	2	1	2	2	3	1	1
Scarce knowledge on cultural practices	3	2	2	2	2	1	3	2	1
Lack of attractive traits	1	2	3	3	1	2	1	1	1

Table 3. List of criteria for the selection of food producing trees and shrubs in semi-arid regions (von Maydell, 1989).

They should meet demands
They should solve problems
They should be accepted by people
There should be no legal restriction
They should have low risk
They should be free from negative properties of effects
They should be adapted to site conditions
They should be easy and safe to establish, with low inputs
They should have fast growth
They should produce high yields
The quality of products should be good
The crops should be compatible with other land use

Table 4. Priority species of leafy vegetables for 5 African Countries in the IPGRI's project on *Germpasm Management of African leafy vegetables for food security in sub-Saharan Africa*.

Priority species	Botswana	Cameroon	Kenya	Senegal	Zimbabwe
<i>Vigna unguiculata</i>					
<i>Amaranthus</i> spp.			(<i>A. dubius</i>)		
<i>Cleome gynandra</i>					
<i>Cucurbita</i> spp.		(<i>C. maxima</i> & <i>C. moschata</i>)			(<i>C. maxima</i>)
<i>Solanum nigrum</i>					
<i>Corchorus olitorius</i>					
<i>Vernonia</i> spp.					
<i>Hibiscus sabdariffa</i>					
<i>Moringa oleifera</i>					
<i>Adansonia digitata</i>					
<i>Abelmoschus esculentus</i>					
<i>Brassica juncea</i>					

Table 5. Major problems for research and development work on underutilized crops.

Problems	Outputs required	Relevant activities
1. Lack of genetic material	Improved availability of seed and other planting materials Crop improvement programmes Improved planting materials derived from traditional varieties	Set up local germplasm supply systems among rural communities Initiate participatory and other improvement programmes to obtain clean planting materials and improved varieties
2. Loss of germplasm and traditional knowledge	Resource base of selected species secured through <i>ex situ</i> and on farm conservation Appropriate traditional knowledge documented and shared among stakeholders	Assess distribution of species and genetic erosion threats Sample germplasm for <i>ex situ</i> maintenance and use Implement on farm conservation through community-based actions Identify and collate traditional knowledge using participatory procedures based on informed consent (including e.g. recipes on uses)
3. Lack of knowledge on uses, constraints and opportunities	Enhanced information on production levels, use constraints and opportunities Knowledge of gender and other socially significant factors identified	Participatory surveys on uses, constraints and opportunities with communities and other levels of the "filieres" AS I SAID EARLIER, IN THE GLOBAL CONTEXT, THIS MAY BE UNCLEAR Analysis of survey data for gender and other socially significant factors
4. Limited income generation	Strategies for adding value and increasing rural incomes using target crops Enhanced competitiveness of selected crops	Development of value adding strategies (through processing, marketing, commercialization etc.)

		Investigate and identify improved agronomic and production procedures
5. Market, commercialization and demand limitations	Enhanced working alliances among stakeholders in “filieres” Improved processing and marketing opportunities identified Improved capacities of marketing associations and producer groups	Strengthen operational links in the “filieres” between seed supply system, processing and distribution stakeholders Develop improved low-cost processing techniques Analyze and identify market opportunities
6. Lack of research and development activities and weak national capacities	Enhanced national capacities to work with neglected and underutilized crops Enhanced information and knowledge on the selected neglected and underutilized crops Methods to improve nutritional values developed and documented	Carry out short training courses ON WHAT for researchers Develop and undertake community-based participatory courses Characterize crops for agronomic, nutritional and market related traits Study formal and informal classification systems Investigate methods of maintaining and enhancing nutritional value Investigate new areas of crop growth
7. Lack of links across conservation and production to consumption “filieres”	“Filieres” established or strengthened Participatory networking procedures established	Hold planning workshops for all stakeholders Establish and strengthen operational links between stakeholders
8. Inappropriate (inadequate) policy and legal frameworks	Raised awareness among policy-makers of issues and options for improved policy and legal frameworks Links to existing rural and economic development projects enhanced	Identify inappropriate policy/legal elements Undertake public awareness actions among policy-makers

		Establish close partnerships with extension workers and others involved in agricultural development
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Figure 1. Representation of minor crops in *ex situ* gene banks (see text for explanation).

