GLOBAL RESEARCH ON UNDERUTILISED CROPS

AN ASSESSMENT OF CURRENT ACTIVITIES AND PROPOSALS FOR ENHANCED COOPERATION

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November, 2000

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EXECUTIVE SUMMARY

This report has been produced to provide a succinct overview of the global research activities on underutilised crops. It is aimed at policy makers, funding agencies and research administrators but it is hoped that it will also be of use to the scientific community.

The report results from a request from a workshop convened by the Genetic Resources Policy Committee for the Consultative Group on International Agricultural Research. The workshop was held at the M.S.S. Research Foundation, Chennai, India in 1999.

It will be seen that the number of countries with dedicated research programmes on underutilised crops is very small. Much of the current activity is carried out through networking arrangements. An analysis suggests that there is a need to re-think the current networks and a strategy for expanded research cooperation should include due attention to information and enhancing research priority setting and cooperative research.

ACRONYMS USED

ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
ARTC	Andean Root and Tuber Crops
AVRDC	Asian Vegetable Research and Development Center
BAMNET	Bambara Groundnut Network
CARIFRUT	Caribbean Fruit Network (IICA)
CATIE	Centro Agronomico Tropical de Investigacion y Ensenanza, Costa Rica
CGIAR	Consultative Group on International Agricultural Research
CIP	International Potato Center
CIRAD	Centre de Cooperation Internationale en recherche agromique pour le developpment, France
CLVNET	Cambodia, Laos, Vietnam Vegetable Collaborative Research Network (AVRDC)
CSC	Commonwealth Science Council
DIFD	Department for International Development, UK
EUCARPIA	European Association for Plant Breeding
FAO	Food and Agriculture Organization of the UN
GFAR	Global Forum on Agricultural Research
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	International Center for Research in Agroforestry
ICRISAT	International Center for Research in the Semi-Arid Tropics
ICUC	International Center for Underutilised Crops
IDRC	International Development Research Centre, Canada
IFAD	International Fund for Agricultural Development
IICA	Instituto Interamericano de Cooperacion para la Agricultura
IPGRI	International Plant Genetic Resources Institute
ISNAR	International Service for International Agricultural Research
IUFRO	International Union of Forest Research Organizations
LGRN	*Lathyrus* Genetic Resources Network (IPGRI)
MESFIN	Mediterranean Selected Fruit Inter-Country Network (FAO)
MEDUSA	Network on Identification, Conservation and Use of Wild Plants in the Mediterranean Region
NARS	National Agricultural Research System
NGO	Non- Governmental Organisation
NLCB	National Lottery Charities Board, UK
REDARFIT	Red Andina de Recursos Fitogeneticos (IICA)
RELAFRUT	Latin American Fruit Network (FAO)
REMERFI	Red Mesoamericana de Resoursos Fitogeneticos (FAO)
REMFRUT	Red Mundial de Frutales Tropicales (FAO)
SAFORGEN	Food Tree Species Network (Sub Saharan Africa)
SAVERNET	South Asia Vegetable Research Network (AVRDC)
SEANUC	Southern and Eastern African Network for Underutilised Species (ICUC/FAO/CSC)
SDC	Swiss Development Cooperation
SGRN	Sesame Genetic Resources Network (IPGRI)
SPC	South Pacific Commission
SPYN	South Pacific Yam Network (SPC)

TANSAO	Taro Network for South East Asia and Oceania (ACIAR/SPC)
TROPIGEN	Red Amazonica de Recursos Fitogeneticos (IPGRI)
UFTANET	Underutilised Tropical Fruits in Asia Network (ICUC/CSC/IPGRI)
UTVAPNET	Underutilised Traditional Vegetables for Asia and the Pacific (ICUC/FAO)
US-AID	Agency for International Development, USA
USDA	United States Department of Agriculture
WAFNET	West African Fruit Network (ICUC/FAO)
WANANET	West Asia and North Africa Network on Plant Genetic Resources (IPGRI)

1. BACKGROUND

Mankind depends on a very limited number of crops to meet the needs of staple diets and on a very limited number of major non-food crops to meet associated needs. In general, a small number of varieties occupy large areas for these cultivated species. Nevertheless in the past human societies depended on a much wider range of species for food, fibre, health security and other needs.

Only about 30 crop species provide 95% of the worlds' food energy whereas over 7,000 species have been known to be used for food and are either partly or fully domesticated . This large array of plant species spans those recognized to be underutilised to those that are recognized as important minor crops. However, with modernisation of agricultural practices many have become neglected due to their being held in low esteem and some have been so neglected that genetic erosion of their genepools has become so severe that they are often regarded as lost crops.

Underutilised crops are found in numerous agricultural ecosystems and often survive mainly in marginal areas. It is timely to review their status because, in recent decades, a number of scientific and economic interests have emerged which focus on lesser-known cultivated species. We identify such interests below.

1. There has been a resurgence in attention being paid to industrial crops and products. In the period of decolonialisation and the efforts which led to the Green Revolution, scientific and development interests moved away from major support to plantation-type agriculture - especially since industrial R & D had led to production of synthesates which could replace many natural plant products. Serious attention shifted towards a wider range of non-food crops and some food crops grown or developed to produce raw materials for a variety of industrial applications. Examples have included kenaf and fibre hemp for fibres; buffalo gourd, crambe, shea-butter, safflower, for oils; guar and guayule for gum, starch, resin and rubber; vernonia for film coatings, and many others.

2. In addition to these industrial applications major developments have occurred in novel applications of traditional crops, especially for animal feed. The latter is of particular importance in Africa where demand for meat in the diet has been increasing very significantly.

3. Other interests in underutilised species have come from developed countries with over-production of staple crops and felt-needs of such countries to put a percentage of lands out of production and/or grow novel crops instead of staples. In the main these interests are led by attention to high value products. This attention has not been mirrored by poorer countries (often over-reliant on a very limited number of food or plantation crops) developing adequate policies for crop diversification.

4. The major impetus to consider underutilised crops, however, has come not from the interests

mentioned above but from a wider recognition that these crops collectively play vital roles in farming systems and in human well-being. This recognition has been slow, but swelling in strength since the Earth Summit of UNCED in 1992, and supported by trends to make agriculture more environmentally sensitive, and sustainable. Other trends include an appreciation of economic development, requiring the involvement of social and ethical dimensions, the rights of indigenous peoples, appreciation by the genetic resources community of the input of farmers in selection, enhancement and conservation of agrodiversity, and by recognition of the need for much more sustainable production systems, especially for fragile ecosystems threatened by drought, desertification or salinization.

In parallel with these trends has been an important paradigm shift in rural development. The integrated rural development approach failed due to it being "top-down" and it evolved logically into a community-driven approach. By the time of the World Food Summit in 1996 the involvement of local communities - as well as focus on the interconnection between agriculture and the environment - had become widely accepted.

This acceptance however is fraught by a lack of policy frameworks, especially government policies on such matters as food pricing or farm subsidies that are often negative to underutilised crops. Additionally trade and market policies rarely reflect ecological values. Nonetheless, at the international level, significant events have fostered underutilised crops. These include the establishment of the International Centre for Underutilised Crops at the urging of 189 scientists from 33 countries in 1987; international symposia on new crops in 1992, and 1996; the FAO Global Plan of Action for Plant Genetic Resources for Food and Agriculture (1996) emphasising the importance of underutilised crops; the Genetic Resources Policy Committee of the Consultative Group on International Agricultural Research (CGIAR) exploring opportunities following a recommendation of the CGIAR System Review that such species be considered in development of an Integrated Gene Management initiative of the international agricultural research centres because of the importance of underutilised crops in household food security. Underutilised crops are also given high priority in the Commodity Chain agenda of the Global Forum for Agricultural Research.

5. Despite the various interests already mentioned, the scientific community has always researched and promoted underutilised crops. Threats of global food shortages prompted the US National Academy of Sciences (NAS) to issue a report on "Underutilised Tropical Plants with Promising Economic Value" (1975). Scientists, as individual champions, continued R & D on the species promoted by NAS and on many others. In recent times NAS issued further reports (e.g. NAS, 1989; 1996), and FAO issued several (e.g. FAO, 1988; Hernandez Bermejo and Leon, 1996). IPGRI issued 24 monographs on individual species in the mid to late 1990s, and ICUC issued two volumes on specific species covering a range of crops (Williams 1993, 1995) and is preparing a further 8 monographs on individual species.

   A very important regional initiative of countries of the Andres Bello Convention (Bolivia, Chile, Colombia, Ecuador, Panama, Peru, Spain and Venezuela) was to assess indigenous minor cultivated species which appear to have economic potential in the short, medium or long- term and over 1,000 species are listed: to date more than 10 individual monographs

have been published (SECAB, 1989).

Another important regional approach has been that of the Plant Resources of South-East Asia programme which, following a preparatory phase, started the compilation of handbooks on useful plants from 1991 (the selection of species is listed in Jansen *et al*., 1991). Handbooks have covered pulses, edible fruits and nuts, vegetables, carbohydrate plants and cereals among food crops as well as forages, auxiliary plants in agriculture and forestry, dyes and tannins and others.

In essence all the reports highlight the value of strategic public goods research opportunities. Despite this, R & D, in general, is lacking on underutilised crops due to government policies barely funding the research and its applications.

6. Lastly, interest has stemmed from concerns over the volume and rate of deforestation and the identification of activities to use all available land to better contribute to rural income, in order to alleviate shortages of fuelwood, small-timber and fodder, especially for income-poor rural communities. A major research thrust worldwide is now focused on multipurpose trees and shrubs for shade, food, fodder and other uses and their incorporation into farming systems such as alley cropping or other attempts such as new rotations to manage decreasing soil fertility and sustainability of production. Numerous innovative applied research projects have used underutilised crops ranging from wider use of underutilised fruits such as *Zizyphus* sp. in dry tropical agricultural systems in India or other fruits in new cropping patterns in hilly land in the Philippines, to the use of underutilised crops in crop-livestock polycultures in many tropical areas that integrate livestock and crops in terms of land, labour, capital and the products.

   Nonetheless new levels of management of traditional crops in more modern agricultural systems alter the traditional models on which they are based: self-sustainability and the integration of component elements in time and space. This principle applies whether to agroforestry systems or to the innovative uses of underutilised crops in mixed cropping. Some successful examples of the latter e.g. use of *Mucuna* (velvet bean) in Benin maize production, should not obscure the fact that major research efforts are needed to transfer traditional agroecosystems into more productive systems. *Caryodendron orinocensis,* an oily nut in the Amazon, illustrates this well: in traditional ecosystems it grows well but in more dense plantings it becomes vigorously attacked by a leaf caterpillar. Multidisciplinary research on the indigenous exploitation systems has to be carried out with new agroforestry production development as well as selection and genetic improvement of the species.

CURRENT STRATEGIC APPROACHES

Underutilised crops are usually considered in relation to their end-use and end-uses are usually grouped into categories: beverage, cereal, oil, spice and flavouring, fruit, vegetable etc. However, the majority of underutilised crops are multipurpose. Probably most underutilised crops for gums, resins, oils and beverages tend to have less than 5-6% of the species with a

single use; those for cereals and medicinals somewhat higher, up to 10-11% with predominately a single use; vegetables and tubers up to 16-17% with a single use; and spices and fruits being special categories with about 25% single use.

Uses also vary from place to place. The legume *Lathyrus* is largely used for fodder in Turkey but in South Asia is mostly used as a food legume and such traditional uses are finding application as a new crop for forage, feed and green manure in Australia. Some species have a range of uses related to a product: for instance, *Sesamum indicum*, an edible oilseed, is used for salad oil and roasted oil but paste is made from milled seeds. However, seeds are used as flavourings; vegetative parts are used for fodder - and sesame products are used in medicines and cosmetics.

In developing strategic approaches there has been the tendency to build on successful experiences with underutilised crops. Successful action mostly resulted from identifying a specific and important single end-use, assembling a substantial germplasm collection followed by selection, breeding and multilocational trials and commercialization. This was the case for *Triticale*, *Amaranthus*, buckwheat and sesame (vide Williams, 1995; Ashri, 1996). In all these cases the need for the product persisted throughout the decades of research and development. Other cases can be cited where collection of and use of landraces in breeding occurred e.g. the fibre ramie (*Boehmeria nivea*) where the Japanese took the lead in the period 1915-1950, or the fibre roselle (*Hibiscus sabdariffa*) where Indians took the lead particularly in the period 1950-1965. Often commercial production was most successful elsewhere e.g. ramie in Brazil or roselle in the Congo and Thailand; but both have reverted to minor status due to competition with synthetics especially long-chained polymer fibres which has since 1950 helped to curtail soft vegetable fibre crops. It is interesting to note that against this background ramie was still being proposed as a plant with promising economic value (NAS, 1975) even though major research was needed on harvesting and degumming. Breeding efforts were less on the sisal crops (*Agave* sp), largely interspecific crosses, and sisals, ancient domesticates of the Americas, have a bleak future. Sisal, ramie and roselle contrast with kenaf (*Hibiscus cannabinus*) where breeding, particularly in USSR (1920-1935); the Dutch in Indonesia in the 1940s; USA linked to Cuba, Guatemala and Honduras (1942-1965); and India (JARI, Barrackpore especially 1955-1970), led to a wide range of adapted varieties which aroused interest as a source of pulp fibre in more recent years or as use for animal food.

It was natural that a commodity approach emerged. Approaches have variously developed into those dealing with one crop or those dealing with several crops of a category (e.g. fruits or vegetables). It is noted that many approaches, in their planning, did not give due cognizance to the need for extension services, which in the main are not concerned with underutilised crops.

The more recent interest of the CGIAR evolved from growing support for sustainable international development strategies; the Convention on Biological Diversity (CBD) with emphasis on conservation, sustainable use and equitable sharing of benefits; the FAO International Undertaking on Plant Genetic Resources and its concept of Farmers' Rights; and the 1996 FAO International Technical Conference on Plant Genetic Resources for Food and Agriculture which incorporated Activity 12 in its Global Plan of Action (GPAFA): "Promoting Development and Commercialization of Underutilised Crops and Species." The Genetic

Resources Policy Committee of CGIAR convened a workshop in February 1999 to examine priority issues in the conservation and use of underutilised species and the potential contributions of the CGIAR in this important area.

Much has been discussed about sustainability and not all people agree on the means to accomplish the tasks. However, CGIAR has in recent years given more emphasis to components of sustainable agriculture and to the complicated interdisciplinary aspects of agroecosystems and natural resources management. In terms of underutilised crops it means assessing indigenous techniques, making conscious efforts to preserve genetic diversity, yet allowing for more efficient cropping. Unfortunately the title of Article 12 of GPAFA with its emphasis on commercialisation is somewhat misleading.

The CBD is also of strategic importance in understanding sustainability issues because, even prior to GPAFA, the wide diversity in traditional farming systems and practices was well recognized. Not only this but there was recognition that useful plants harvested from the wild will contribute to food security and life support in times of stress. Discussions associated with CBD emphasised the need to inventory, assess and understand traditional farming systems and extractivism from the wild and placed heavy emphasis on the capture of traditional knowledge.

A further strategic input in recent years has been the trend to adopt a broad landscape approach, particularly by conservationists who recognize that significant elements of diversity now often remain only in agricultural environments which contain fragments of original wildlands.

A number of these themes were summarised by experts considering the implementation of a number of the Articles of CBD (DIVERSITAS, 1998). It is apparent that from a strategic planning point of view there are diverse opinions on priorities for action depending on whether the opinion-makers are concerned primarily with agricultural production or with conservation. This diversity of opinion does not provide a clear framework for those associated with underutilised crops. Nor do existing basic studies on traditional agroecosystems deal adequately with inequitable income distribution. There are too many naive statements that promotion of certain crops/products will create employment opportunities through increased demand for goods and services by the agricultural sector. All too frequently writings on growth and equity are ideological. In terms of underutilised crops being part of the strategy for diversified agroecosystems in marginal areas, greater labour has to be applied per unit of land and the cost of food production can rise along with food prices meaning perpetuation of subsistence living rather than alleviation. Alleviation can only come from national policies to achieve technologically sound agricultural progress matched to growth of population and attention to poverty alleviation. Such policies also need rapid diffusion to impact on equity. Strategically, promoters of diversified traditional agriculture and underutilised crops must recognize that nations, in setting policy, have a prime responsibility for effective development which includes growth in rural incomes and growth in non agricultural employment which is related. The key input will be the clear recognition of the percentage contribution to the nation's food security of the traditional cropping systems - collectively estimated to account for 20% of the world's food supply. Local studies, however valuable, rarely seem to take this broader approach and the promotion of diversified smallholder systems as a result of such studies are often viewed as

esoteric and not very practicable.

There remains, in relation to strategy, differences between agriculturists who are relatively unconcerned about traditional agroecosystems because they do not appear to be necessary for highly productive agriculture, conservationists who do not consider such ecosystems in their remit and those who wish to promote traditional agriculture. The divergent opinions in part, explain the slow implementation of practicable on-farm conservation of genetic diversity, the implementation of Farmers' Rights and slow progress under the CBD on equity issues. The lack of widespread understanding among development agencies of links between agriculture and biodiversity is also legion (Srivastava *et al*., 1996; Heywood, 1998).

Many development projects and networked efforts on particular crops have attempted to promote underutilised species because markets are foreseen for the produce. If marketing is important it cannot succeed in a developing country without a well-articulated market system. This must be able to reflect accurately the changes in supply, demand and production; and frequently such marketing intelligence is not in place.

1.1 SCOPE OF THIS REPORT

When the Genetic Resources Policy Committee of CGIAR held a workshop in 1999 it was evident that a global overview of activities on underutilised crops did not exist. Also priorities had been determined in diverse contexts and no objective assessment existed. ICUC and IPGRI agreed to produce an overview and develop proposals for further action which might be considered by policy makers, research administrators as well as the scientific community. This report is the result of that agreement.

The analyses and discussions which follow are based mostly on underutilised food crops, or those underutilised crops that produce products used in the food industry. Emphasis, at this time, was placed on these particular crops because of the predicted growth in human population and the prospects of food insecurity. Although improving food security and alleviating malnutrition are international imperatives, attention also has to be paid to those plant resources related to the diversification of agriculture and these include non food crops. This wider range of diversity, very often underutilised, is essential to protect agriculture and the environment in the face of global change in environmental conditions.

With reference to the wider range of underutilised cultigens, the literature showed that forages and species of value in environmental stabilisation and also medicinal plants present a number of challenges unique to those groups. Including them in the present survey would have changed the relatively sharp focus which emerges for underutilised food crops. Essentially these other underutilised crops/species require analyses and reports of their own.

In many cases forages and medicinal plants relate to species harvested from the wild for a range of purposes; and most represent truly wild, or at best semi-domesticated species. Especially for medicinals, attempts to cultivate them are in varying stages of development and priorities

contrast between those which will produce compounds for the pharmaceutical industry and those which can be used as standardised preparations of raw material for use in primary health care.

In conducting the survey, ICUC has not become involved in categorising species into groups such as minor crops, neglected crops or alternative crops. In the main, the species considered are domesticated rather than wild, or in some cases so associated with man and his environment that they have undergone some selection.

The starting point for the analysis was basic information on a country basis provided to FAO as preparatory input to the 1998 report "The State of the World's Plant Genetic Resources for Food and Agriculture". In that report a table of selected underutilised crops included a summary of their uses, state of breeding and priorities for research based on data from FAO, ICUC and IPGRI, but this was indicative rather than definitive.

Following the abstracting from FAO data, the analysis was broadened using a wide range of published research in the ICUC library and also the large amount of grey literature of reports which have had limited distribution.

This permitted ICUC to summarise the existing activities, list valid defined priorities for species, assess the state of networking arrangements and propose a strategic approach for the future.

2. EXISTING ACTIVITIES SUMMARISED

Interest in diversifying crops around the world has derived from a long history of plant introduction, in which crops have been tested out far from their original areas of diversity. Many species diversified further in new areas and formed the basis of much of the staple food production as well as new agricultural production systems (such as oilpalm in SE Asia, cocoa in West Africa, kiwi fruit, pineapple and other major fruits in many parts of the world). However, agriculture in the tropical world, with few exceptions, suffered from lack of mechanisms to introduce, test and understand less important species; and where a number of such less important species were tested the germplasm base was often so limited and narrow that they were not successful. At the same time the institutional framework in less developed countries was such that the research and experimentation did not have the capacity to extend to such crops.

In the past 30 years there have been major efforts to make the national agricultural research systems (NARS) more productive through the build-up of national capabilities for the generation of technology. Any examination of data available over this time, from FAO or ISNAR, shows that human capacity building in the developing countries was largely a phenomenon of the 1970s and 1980s onwards, that in terms of finance many NARS were poorly funded, and that many NARS were relatively weak. It is not surprising therefore that when the scientific community started to promote the need to apply knowledge on underutilised crops (from the mid 1970s) that the very research systems suited to do the applied research were unable to consider such things: rather they were faced with providing adequate research and extension related to domestic food production and tropical plantation crops, although even the latter suffered during

decolonialisation.

Experience has shown that investments in public institutions (and reform of these when necessary) have increased the capacity of the agricultural sector to respond to economic forces. NARS still have many problems to cope with - population, underdeveloped market systems, distorted incentives and pricing (indicating what is recognised as “perverse subsidies”), and others - but there are marked signs of technical and institutional changes. The question that has to be asked is, "Can the NARS cope adequately with underutilised crops?" In the majority of cases the answer is "No." The second question to ask then is "When will they be ready to do so?", and this is not so readily answerable.

Having pointed this out, it will not be surprising that the number of national programmes involved with underutilised crops is small. Added to the weakness factor of the NARS are constraints in expanding R & D on underutilised crops. From the table in the FAO's State of the World's Plant Genetic Resources for Food and Agriculture (1998) the following are frequent constraints:

- limited germplasm available.
- lack of technical information.
- lack of national policy.
- lack of interest by researchers, agriculturists and extension workers.
- lack of producer interest.

It was recognition of such constraints that led to the creation of ICUC in 1988 which has, over 12 years, promoted interest in and provided technical information on a wide range of species. When the preparatory process for the FAO (1996) International Technical Conference on Plant Genetic Resources for Food and Agriculture held regional meetings, all identified the need for more attention to minor and underutilised crops in conservation and utilisation programmes.

Information gathered by FAO in the above-mentioned preparatory process noted the great value of underutilised crops to small farmers (and especially in multicropping agricultural systems) and also that women are often the ones with prime responsibility for the production of subsistence crops that are essential to household food security.

2.1 Developing Countries

Many countries, in providing information to FAO, stated their interests in underutilised crops. Those developing countries with nationally-approved coordinated programmes are listed in table 2-1. They are all part of NARS structure, but are very limited in number.

Table 2.1 Developing countries with national programmes on underutilised crops

	Basis	Comments
Bangladesh	Part of 5-year plan	Limited number of species: fruits, minor legumes and sesame
Brazil	National coordinated project	Clear list of priorities. Consortium of Government Agencies
China	Projects under 5-year plans	Limited number of species: Buckwheat, local fruits and sea buckthorn
India	National coordinated project	Clear prioritized list of priorities. Ministry of Agriculture
Kenya	National programme	Planning to establish national programme
Nigeria	National programme	Planning to establish national programme
Philippines	National programme	Not currently being implemented
South Africa	National programme	In the process of establishing projects on indigenous species for traditional farming

The developing countries are served to a degree through a number of externally funded projects or networks (Table 2.2).

Table 2.2 Networks serving developing countries for cultivation and utilisation of specific underutilised crops (for acronyms see page 3).

	No. of countries	Lead organisation	Notes
Fruits			
REMUFRUT (global)		FAO	
- MESFIN (Mediterranean)	13	FAO	1
- MECINET (Citrus in the Med.)	11	FAO	
- UTFANET (Asia)	10	ICUC	2
- CARIFRUT (Caribbean)	15	IICA	3
- RELAFRUT (Latin America)	under formation	FAO	4
- WAFNET (W Africa)	under formation	ICUC/FAO	
- linked also to REMERFI, TROPIGAN, REDARFIT & WANANET			5 6 7, 8
Nuts		FAO	9
FAO-CHIEM (Inter-regional)			
Roots/tubers			
- ARCT (Andes)	5	CIP	10
- TANSAO (SE Asia/Pacific)	8	SPC	11
- SPYN (S.Pacific)	7	SPC	12
- roots /tubers also included in SEANUC			13
Vegetables			
- UTVAPNET (Asia/Pacific)	under formation	ICUC/FAO	14
- CLVNET (Indochina)	3	AVRDC	15
- SAVANET (S Asia)	6	AVRDC	16
All priority underutilised crops			
- SEANUC	11	ICUC/FAO/ CSC	17
Food trees			
- SAFORGEN (Sub-Saharan Africa)	under formation	FAO/IPGRI/ICRAF/IUFRO	
Others			
- SGRN, Sesame network (Asia)	8	IPGRI	
- Cactus pear network (global)	21	NGO IPGRI/ICRISAT/ICARDA	
- LGAN, Lathyrus network (global)	16	NGO	
- BAMNET, International bambara groundnut network (Africa)	-	Informal	

Notes on underutilised priority species of the networks

1. Includes *Annonaceae*, fig, guava, loquat, persimmon, pomegrante, longan, carambola, litchi, papaya, passion fruit and feijoa
2. Includes jackfruit, pummelo, mangosteen, ber, guava, anona, soursop, lime, carambola, durian
3. List is not available at the present time
4. Includes Aguacate (*Persea americana* M.), Mango (*Mangifera indica* L.), Pina (*Ananas comosus* M.), Papaya (*Carica papaya* L.), Guayaba (*Psidium guajava* L.), Passifloras, Anonaceas and native fruits of America.
5. Includes *Annonaceae, Caricaceae, Sapotaceae*

6. Includes *Bactris, Theobroma grandis* and *Carica*
7. Includes native Andean fruits
8. Includes *Pistacio* and *Ceratonia*
9. Includes almond, walnut, *Pistacio, Castanea*
10. *Ullucus, Oxalis, Tropaeolum*, and others
11. Taro
12. Yam
13. Includes *Solenostemon, Plectranthus, Tylosema, Harpagophytum, Colocasia, Sphenostylis, Xanthosoma, Vigna* spp.
14. Taro (vegetable), *Amaranth, Momordica*, lablab, *Ipomoea aquatica*
15. Includes vegetable soybean, yardlongbean and *Ipomoea aquatica*
16. Includes okra and minor cucurbits
17. Includes *Cucurbita* spp., *Vigna subterranea*, *Lablab purpureus*, *Amaranthus* spp., *Cloeme gynandra*, *Solanum nigrum*, *Citrullus* spp., *Corchorus* spp., *Lagenaria* spp., *Cucumis* spp., *Solenostemon rotundifolius*, *Plectranthus esculentus*, *Tylosema esculentum*, *Harpagophytum procumbens*, *Colocasia esculenta*, *Sphenostylis stenocarpa*, *Xanthosoma sagitifolium*, *Vigna* spp., *Tylosema fassoglense*, *Eleusine coracana*, *Setaria italica*, *Echinochloa* spp., *Chenopodium quinoa*, *Opuntia Ficus-indica*, *Ziziphus mauritiana*, *Ricinodendron rautanenii*, *Psidium guajava*, *Sclerocarya birrea, Strychnos spinosa*, *Strychnos cocculoides*, *Vangueria infausta*, *Uapaca kirkiana* and *Adansonia digitata*.

Table 2.3 illustrates a selection of developing countries that have some action on specific underutilised crops. It will be noted a major interest appears to be diversifying the diet through sustainable use of fruits and vegetables.

Table 2.3 Developing countries with some research interest on expanding use of underutilised crops (other than those with active national programmes listed in Table 2.1)

Crop group	
Fruits	
	Angola
	Jordan, Turkey, Syria, Egypt, Yemen
	Pakistan, Sri Lanka
	Philippines, Thailand, Indonesia, Malaysia, Vietnam
	Cuba, Costa Rica, Antigua/Barbados, Guatemala, Honduras, Mexico, El Salvador, Nicaragua, Panama
	Ecuador, Brazil
Vegetables/pulses	
	Nigeria, Ghana, Zimbabwe, Namibia
	Pakistan, Nepal, Sri Lanka
	Thailand, Indonesia, Vietnam, Philippines
	Ecuador

Cereals/pseudocereals
Andean countries
Cuba, Guatemala
Ethiopia

Roots and tubers
Andean countries
Pacific States

Oil seeds
Ethiopia

Other than countries listed in Table 2.1, only 8 others have a stated aim to develop a national programme on underutilised crops: Angola, Ghana; Cuba, Guatemala, Costa Rica; Vietnam, Pakistan and Turkey.

Almost certainly the justifications for any further development of underutilised crops in developing countries are primarily:

1. to ensure sustainable livelihood and food security, and
2. to adapt to changing environments and to satisfy environmental demands in difficult areas.

There is virtually no continuing research interest in developing countries on industrial crops, although a number of these countries have been linked to such research in developed countries from time to time. Other than attempts to satisfy export markets by enhanced production of particular products, in the main, industrial applications need a great deal of planning, research investment and secure markets. There will always be cases where economies dictate a single focus. For example *Gnetum* is collected from the wild in Cameroon and there are huge exports to Nigeria. An urgent domestication process has been expressed for this species.

2.2 Developed countries

Numerous developed countries have major research interests on underutilised species. This research can be categorised as follows:

1. Development of new industrial products through agro-industrial research producing non-food use products, especially oils, fibres and starches, other bio-active compounds.

2. Development of new industrial products for food use especially oils and starches.

3. Expansion of food offerings in supermarkets through development of alternative crops.

4. Development of alternative crops for export.

5. Description and use of heritage varieties as part of the human culture.

6. Expansion of an underutilised species to improve production for food in difficult environments.

Most of the research input focuses on 1-3 above. Developed countries vary in their approaches. The approach may be through a coordinated national programme on underutilised crops as in the case of Australia, France, Germany, Israel, Italy, Netherlands, UK and USA; or it may be through particular project focus as in many of the other developed countries, especially Canada, Chile, Japan; or New Zealand, Cyprus, Belgium, Denmark, Ireland, Greece, Portugal and Spain. There is a degree of competitive public funding for much of the research e.g. through USDA in USA, or through the European Community and/or Government sources in Europe. In nearly all cases the private sector is involved in the research and to a degree in the funding. Some industrial programmes are carried out wholly by the private sector.

Examples of the six categories above are:

1. EU-VOICI: Vegetable oils in chemical industries; USDA research on a wide range of oil and latex species; kenaf fibre in Australia.

2. Trials in Austria, Denmark, France, Germany, Hungary, Italy, Spain, Russia for fructose syrup from underutilised root crops.

3. Trends throughout for perceived-healthy foods, and commercialisation of products from underutilised crops.

4. Trials of exotic fruits in New Zealand.

5. EU-RESGEN: Underutilised fruit species in France, Greece, Italy and Spain.

6. Chile-FONDEF with USA, Greece, Spain and Turkey, for development of drought tolerant species for arid and semi-arid zones e.g. pomegrante.

2.3 Donors

A number of the developed countries have acted as donors for enhancing R & D of underutilised crops in developing countries. Noteworthy have been US-AID, GTZ-Germany, Italy, SDC-Switzerland, DFID-UK, NLCB-UK, the Leverhulme Trust and ACIAR-Australia, as well as the European Community. In some cases national programmes of developed countries have joined forces with the projects e.g. France-CIRAD project on *Passiflora* in the Andes or the Royal Veterinary and Agricultural University of Denmark on *Pachyrhizus* research.

However, there is no clear picture of bilateral aid nor any consortium to ensure continued support. The multilateral agencies are also involved, especially FAO, and more recently ADB and IFAD. Current support from CSC and SPC, as intergovernmental agencies, is noteworthy as was that of IDRC in the past.

The Overseas Development Institute, UK noted that recent research on underutilised species suggests that a major gap exists between the priorities of development agencies and the way smallholder farmers view such species elsewhere in the world. It is suggested also that this leads to the major promoters of such research remaining individual enthusiasts rather than them being considered seriously by aid agencies (ODI, 1997).

3 CURRENT PRIORITY CROPS

It is well known that determination of priorities for underutilised crops depends upon opinions, especially those of scientists who have been researching particular ones. In some cases groups of national experts have been involved and consensus reached on those species which merit national research input. The data gathering by FAO for the State of the World Report on Plant Genetic Resources (1998) also includes a limited number of priorities.

It should be noted that even participatory prioritisation leads to widely divergent results, especially in terms of how many species require research attention. Table 3.1 shows the results from exercises conducted in Africa in the past 2 decades.

Table 3.1 Prioritisation of traditional crops in Africa proposed by national programmes.

Year	Lead organisation	Number of species	Focus
1984	FAO	144	Sub-Saharan
1988	FAO	63-110	Sub-Saharan
1992	ICUC	10	W. Africa
1995	ICUC	34	S. & E. Africa
1997	ICUC	76	W. Africa

Assessment of a wide range of the major published and unpublished reports leads the authors to summarise a list of priorities for food crops (Table 3.2: 1-4)

In Table 3.2 the crops are grouped according to major use as cereals/pseudocereals, fruits and nuts, vegetables and pulses and roots and tubers. It was not possible to produce a meaningful list of priorities for industrial applications for the majority of the less developed regions, although where a listed priority underutilised food crop has industrial applications, this is so annotated. However, this is discussed further after the listings of food crops.

It will be immediately apparent from Table 3.2 that a large number of species justify priority research. To accord priorities within these listings as high, medium or low would be impossible without a major exercise involving scores of scientists and development officers. However, the listings provide a basis on which further strategy can be formulated.

It should also be noted that in any cases where exotic species are underutilised e.g. *Caria papaya* in E. Asia or even where diversified species are underutilised e.g. walnut, almond and fig in several parts of the Mediterranean, that these are not necessarily underutilised in other parts of the world.

Table 3.2:(1) Priority underutilised cereal and pseudocereal crops

	Indigenous or major secondary diversity	**Exotic**
ASIA		
	Fagopyrum esculentum	*Amaranthus* spp.
	Panicum miliaceum	*Eleusine coracana*
	Panicum miliare	*Triticale*
	Setaria italica	*Chenopodium quinoa*
	Echinochloa frumentacea/utilis	
	Paspalum scrobiculatum	
AFRICA		
	Eleusine coracana (E,S)	*Panicum miliaceum*
	Digitaria exilis (W)	*Setaria italica* (E,S)
	Echinochloa spp (E,S)	
	Triticale (E,S)	
MEDITERRANEAN/S.W. ASIA		
	Setaria italica	*Triticale*
	Primitive hulled wheats	
LATIN AMERICA		
	Chenopodium quinoa	*Triticale*
	C. pallidicaule	
	Amaranthus caudatus	

Table 3.2:(2) Priority underutilised fruits and nuts species

(* also indicates crops with industrial applications -- ** indicates commercial use in part of the particular region)

	Indigenous or major secondary diversity	**Exotic**
ASIA		
1. EAST		
	Dimocarpus longan	*Passiflora edulis*
	Carya cathayensis	*Carica papaya*
	Hovenia dulcis	
	Vitis spp.	
2. SOUTH/SOUTHEAST		
	Benicasa hispida	*Carica papaya*
	Citrus grandis	*Passiflora edulis*
	Other citrus e.g. lime	*Annona muricata*
	Aeglos marmelos	*sqoamosa/reticulata*
	Artocarpus heterophyllus	*Litchi chinensis*
	Salacca zalacca	*** Anacardium occidentale*
	Garcinia mangostana	
	Nephelium lappaceum	*** Psidium guajava*
	Averrhoa carambola	*Dimocarpus longan*
	Durio zibethinus	
	Zizyphus mauritiana	*Borassus aethiopicum*
	Canarium spp.	
	Terminalia koernbachii	
	** Tamarindus indica*	
	Embilica officinalis	
MEDITERRANEAN/S.W. ASIA		
	** Ceratonia siliqua*	*Zizyphus mauritiana*
	Punica granatum	*Diospyros kaki*
	Pistacia lentiscus	*Eriobotrya japonica*
	Ficus carica	*Casimiroa edulis*
	Prunus amydalus	
	Juglans regia	
	Opuntia ficus-indica	
	Castanea spp.	

AFRICA

1. EASTERN/SOUTHERN

Borassus aethiopicum
** Balanites aegyptiaca*
Zizyphus mauritiania
Vitellaria paradoxa
Uapaca spp.
Tamarindus indica
Sclerocarya birrea (caffra)
Strychnos spp. *e.g. cocculoides*
Vangueria spp.
Adansonia digitata/grandidieri
Dovyalis spp.
Opuntia ficus-indica
Anacardium occidentale
Psidium guajava
Passiflora edulis

2. WESTERN

Zizyphus mauritiania
Diospyros mespiliforme
Dacryodes edulis
Adansonia digatata
Uapaca spp.
Blighia sapida
Strychnos spp.
Psidium guajava
Anacardium occidentale

AMERICAS

1. MESOAMERICA/CARRIBBEAN

Annona cherimolia/diversifolia
muricata/squamosa
Pouteria sapota
Feijoa sellowlana
Spondias purpurea/cythera
Mammea americana
** Bactris gasipaes*
Cucurbita foetidissima
** Manilkara zapota*
Passiflora edulis

2. SOUTH AMERICA (A = especially Andes)

** Bactris gasipaes*
Theobroma grandiflorum
Passiflora edulis/quadrangularis
P. mollissima (A)

P. ligularis (A)
Cyphomandra betacea (A)
Solanum muricatum (and A)
S. quitoense (A)
Annona cherimolia/muricata (and A)
Carica pubescens and hybrids (and A)
Feijoa sellowiana
Eugenia stipitata
Euterpe oleracea
** Manilkara zapota*
Couepia longipendulata
Spondias lutea
Psidium angulatum
Paullinia cupana
Juglans-indigenous species.

Table 3.2:(3) Priority underutilised vegetable and pulse crops
(* indicates crops with industrial applications)

	Indigenous or major secondary diversity	**Exotic**
ASIA		
	Ipmoea aquatica	
	Amaranthus spp.	*Vigna subterranea*
	Divers local bamboo spp.	*Crambe cordifolia*
	Corchorus spp.	*Lagenaria* spp.
	Rorripa indica	
	Chenopodium album	
	Emilia spp.	
	Basella rubra	
	Curcuma spp.	
	Momordica spp.	
	Vigna umbellata	
	V. aconitifolia	
	V. angularis	
	V. umbellata	
	Moringa oleifera	
	Phytolocca acinosa	
	Macrotyloma uniflorum	
	Lathyrus spp.	
	Psophocarpus tetragonolobus	
	Canavalia spp.	

Lablab purpureus
Mucuna spp.
Vegetable *Glycine*

AFRICA
(A = All Africa S. of Sahara; E,C,W,S = Eastern, Central, Western, Southern)

Celosia spp. espec. *argentea*
Anaranthus spp. (A)
Lablab purpureus (A)
Solanum americanum/nigrum (A)
S. aethiopicum/S. macrocarpus (A)
Corchorus spp. (A)
Hibiscus sabdariffa (A)
Voandzeia subterranea (A)
Parkia biglobosa (W,E)
Gymnandropsis synandra (W,C,E,S)
Colocasia/Xanthosoma leaves (W,C)
Talinum triangulare (W)
Crotalaria spp. (E)
Brassica carinata (E)
* *Vernonia* spp. (W,C,E,S)
Basella alba
Citrullus local spp. (S)
Cucumis local spp. (S)
Telfairia spp. (A)
Abelmoschus spp. (W)

Cucurbita spp. (A)
Lagenaria spp. (A)
Bidens pilosa (A)
Canavalia ensiformis
Mucuna spp. (A)
Lablab purpureus (A)

LATIN AMERICA/CARIBBEAN
Physalis philadelphicus
Pachyrhizus spp.
Lupinus mutabilis
Opuntia spp.
Bactris hearts
Euterpe hearts
Chamaedorea tepoiilote hearts
Cnidoscolus chayamansa
Cucurbita spp. espec. squashes

MEDITERRANEAN/S.W. ASIA
Eruca sativa
Lathyrus sativus
Lupinus spp.
Cynara cardunculus

Table 3.2:(4) Priority underutilised root and tuber crops

	Indigenous or major secondary diversity	Exotic
ASIA		
	Colocasia esculenta	*Xanthosoma sagittifolium*
	Alocasia spp.	*Pachyrhizus erosus*
	Dioscorea spp.	
AFRICA		
	Dioscorea spp. (W,C,E)	*Colocasia*
	Vigna vexillata (E)	*Xanthosoma*
	Sphenostylis stenocarpa (E,S)	Exotic *Dioscorea* spp.
	Solenostemon rotundifolius (W,E,S)	
	Plectranthus esculentus (W,E,S)	
	Tylosema fassoglense (E,S)	
	T. esculentum (E,S)	
	Harpagophytum procumbens (E,S)	
LATIN AMERICA		
	Dioscorea spp.	
	Xanthosoma spp.	
	Pachyrhizus erosus / tuberosus	
	Arracacia xanthorrhiza	
	Calathea allouia	
	Ullucus tuberosus	
	Canna edulis	
	Tropaeolum tuberosum	
	Oxalis tuberosa	

There are a number of reasons why a clear list of industrial priorities cannot be made at this time. They are:

1. Without a recognised national programme on underutilised crops any focus on an individual one for industrial purposes is unlikely unless there is an overwhelming need due to loss of major export earnings and the need for a replacement product. Such a decision is rarely made in the agricultural research planning sector.

2. There are a number of cases where underutilised crops have been promoted by donors or

bilateral aid and the aid package includes the industrial development. Examples would be: support by UNIDO to explore oil extraction and refinement from *Balanites aegyptia ca*, in the Sudan; or USAID support to new crop work in NW Argentina to test a range of fibre, and oilseed species.

3. In many cases the industrial applications depend on very specific postharvest technology, usually processing, and many research programmes have not developed the strategic planning for developing a crop in which production, processing and marketing are integrally linked. This was the case with early work on *Triticale* (Johnson, 1990). Certainly in developing countries complex processing of a product, or a range of processing options (as for amaranth grain: Williams and Brenner 1995), will determine the success of the R & D on the crop and its acceptance.

4. Where a developing country has a nationally recognised programme on underutilised crops, there is more likelihood of progress in incorporating a number of species for industrial applications. India provides an excellent example with focus on food plants, plants for extreme environmental or emergency food situations and research on guayule (*Parthenium argentatum*), jojoba (*Simmondsia chinensis*), guar (*Cyamopsis*), *Jatropha*, *Cuphea* and others, including alcohol production from tuber crops (Gautam, Sharma, Joshi and Kochhar, 1999). China has an especial interest in *Hippophae rhamnoides* and has an international institute for research and training on this crop. Several programmes other than India and China also express interest in a limited number of industrial crops, safflower being a good example.

5. Most of the advanced research and development on industrial uses of underutilised crops is undertaken in developed countries. This is backed by deliberate policy to satisfy new needs in the food industry and produce new products for industry, for instance the European Community support for new vegetable oil derivatives. When deliberate policy, research support and commercial R & D are combined extremely sophisticated research can be carried out which is not readily possible in a developing country. Such programmes can focus on many approaches whether development of a new product from an established crop, development of a totally new crop through domestication (e.g. *Vernonia* as a source of exopy acid as a solvent in epoxy coatings and resins) or production of an existing established commercial product from a different crop species, usually a recognised underutilised one. These research programmes in developed countries are thus backed by good knowledge of current and potential market demands, opportunities for developing markets in relation to profitability and technological enhancements in production and quality of products.

6. In relation to underutilised crops in the less developed countries, it is clear that interests in pursuing new research in this area is largely a result of sentiments expressed in international fora over the past two decades for such research to be part of the overall goal of food security. This focus should continue to guide any international support to underutilised crops which might be forthcoming. However, it should not negate any effort on an industrial crop in a developing country when national policy has been defined, and support is mobilised, in view of the employment opportunities and the benefits to the particular economy. But it must

be clear at the policy level what are the diverse needs and levels of sophistication required in processing and postharvest technology. Some recognised priorities are shown in Table 3. 5.

Table 3.5 Some high priority industrial underutilised crops

Oil seeds	
Perilla frutescens	S. Asia
Ricinodendron rautanenii	E.S. Africa
Carthamnus tinctorius	Asia, E.S. Africa, S.W. Africa
Vernonia spp.	E.S. Africa
Sesamum indicum	Asia, E.S. Africa
Ricinus communis	Mediterranean, E.S. Africa
Cuphea spp.	Med., S. Africa, S. Asia
Simmondsia chinensis	Med., S. Asia, Latin America
Jatropha curcas	S. Asia, E. Africa
Citrullus colocynthis	S. Asia
Euphorbia lagascae	Med.
Lesquerella fendleri	Latin America
Acrocomia aculeata	S. America
Bactris gasipaes	C., S. America
Butyrospermum paradoxum	W., E. Africa
Balanites aegyptiaca	E. Africa
Latex/rubber/gums	
Parthenium argentatum	S. Asia, Med., Latin America
Couma utilis	S. America
Cyamopsis	E. Asia, S. Asia, S. Africa
Fibres	
Hibiscus cannabinus	Med., Africa, Latin America
Starch/sugar	
Metroxylon sagu	S.E. Asia
Ceratonia siliqua	Med.
Dyes	
Bixa orellana	C., S. America
Carthamnus tinctorius	Med., S. Asia, S.W. Asia
Hibiscus sabdariffa	Med.

Mastic

Pistacia Med., S.W. Asia

What is apparent from the listings of priorities is the wish to enhance production of a number of crops in specific regions where the production technology is known or at least more advanced in another part of the world.

This has important implications on developing any global strategic approach. Strategy can therefore include technology transfer in such cases, using a variety of mechanisms from South-South cooperation to expanding networking arrangements or through focused aid inputs. However, there are many crops where existing technology is non-existent other than traditional production. Strategy development in these cases will have to be based on sharply focused goals, a time-frame for expected research products, and a clear policy framework at the government and research levels.

3.1 Sharpening the criteria for priority setting

In reveiwing existing documentation the criteria used to define priority species varied widely. However, there were sufficient commonalities to conclude that the species listed in Tables 3.1 (1-5) are largely valid.

The major international promoters have somewhat different approaches. IPGRI's concern is on "Neglected and Underutilised Species" and to develop priority action plans for their sustainable genetic conservation and making suitable genetic diversity available for use. ICUC's concern is to widen the range of useful plants used in farming systems and promote appropriate technology in order to raise and sustain overall productivity and contribute to food security and poverty alleviation - and to impact in a positive way on the conservation of biological diversity. Both organizations act in a partnership way whilst carrying out project-based research and promotion.

Hence criteria used in regional and other meetings have reflected these approaches and included items associated with the germplasm/genepool base as well as current production constraints, germplasm enhancement needs, agro-ecological constraints, and postharvest processing and marketing.

A consensus of the criteria for priority setting is shown in Table 3.3, and this will be a useful summary as strategy development proceeds.

Table 3.3 Criteria for Selecting Priority Crops for a Nation and Region

1. Policy framework
   - Importance to NARS
   - Importance to regional and sub-regional collaborative research

2. Germplasm
   - Availability of germplasm
   - Genetic erosion perceived
   - Current genetic conservation status
   - Potential demands for germplasm

3. Acceptability
   - Local preferences/consumption
   - Market potential
   - Rural income generation
   - Acceptability in broader markets

4. Uses
   - Nutritional value
   - Cultural/religious affinities
   - Potential diversification of products

5. Production
   - Wide adaptability
   - Cropping systems suitability (including agroforestry)
   - Satisfies need for crop diversification
   - Pest/disease situation
   - Production technology

6. Postharvest
   - Harvest/storability/handling
   - Processing technology
   - Products in relation to markets

For a government official, priority setting is likely to fall within the framework of:

- enhancing supplies of deficit products in specific areas such as vegetable oils or other food purposes,
- addressing stressed ecosystems,
- enhancing national input to international trade,
- increasing the innovative products with a market potential, and
- using crops for new purposes to enhance the well-being of communities.

In view of concerns about sustainability and the environment the public sector remains a major and logical focus (Smith, 1988); this needs to be recognised at the outset.

Furthermore government officials need to recognise that when a priority is accorded to an underutilised crop for industrial purposes the commitment is needed at the beginning for the suitable postharvest handling including processing mechanisms. If priority is accorded for complex and new industrial products then almost certainly a strategy for commercialisation has to be developed at the beginning and this involves commitments as in Table 3.4. It is important that due cognizance is given to this to avoid failures due to inadequate market analysis or products costing more than anticipated.

Table 3.4 Items to consider for the commercialisation of an underutilised crop and its products (Modified from Australian New Crops Newsletter 1997 and development from Wallis, Wood & Byth, 1989)

1. Priority backed by financial commitment to its development
2. Recognition that the R & D is high risk
3. Recognition that IPOs might be needed
4. Assessment of marketing potential
5. Assessment of production potential
6. Establishment of an interdisciplinary team
7. Agreement on resource requirements and action plans
8. Project monitoring and problem solving
9. Establishment of economic benchmarks
10. Agreement to proceed or abandon research if benchmarks not reached
11. Trial production for trial marketing/processing/packaging
12. Experimental production.

These items relate to the industry and the market place. Meadley (1989) stressed the need for monitoring change at the farm level during the process.

4 NETWORKING

In recent decades much has been written about the value of networks, particularly when related to a specific crop commodity. In fact, many of the successes of international agricultural research through the CGIAR have been developed and promoted through networks. Essentially networks comprise a group of partners which set a research agenda, mobilize support, and build a cooperative inter-disciplinary, critical mass of researchers, thus filling gaps where individual partners may not have adequate strength. Networks also pool limited resources and share the workload amongst members, and network members share the outputs and benefits.

Networking for underutilised crops needs a great deal of clarification since a major current international goal is widely recognised as using such crops to broaden the base of agriculture and incorporating them into sustainable utilisation to meet the nutritional and income needs of local people or even needs at the national level. Nonetheless many nations would like to see as a goal

the enhancement of a particular underutilised commodity in order to produce export earnings from particular products, such as a specific vegetable oil, or a focused market-niche product.

Any historical survey of diverse networking mechanisms for individual underutilised crops shows that it takes a minimum of 20 years to lead to really productive results, and this includes the internationalisation of the research. Williams (1995) cited the cases of triticale and grain amaranth but these two examples also had major infusion of funding, particularly for the testing network and the germplasm enhancement. It remains to be seen if crop networks of more recent origin will generate the same external inputs, and lead to similar major impacts in similar time frames.

It is pertinent to review the existing networking arrangements to identify constraints and to make proposals for possibly more effective arrangements.

4.1 Categorising the Networks

Existing networks can be categorised in 3 ways:

1. Crop coverage

- A single crop - sesame, *Lathyrus*, buckwheat, bambara groundnut, yam bean, cactus pear, taro, yam.

- Multiple crop species - fruits, cucurbits, amaranths (grain & vegetable), lupins (grain & pasture)

- Multiple crop species in specific geographic regions - Andean roots and tubers, S. Asian vegetables, W. African tropical fruits, Asian tropical fruits, Asian vegetable crops, Caribbean fruits, Mediterranean fruits, Mediterranean nuts, underutilised wild Mediterranean species, underutilised crops of S. and E. Africa

- Multiple underutilised crops as part of other networks - e.g. crop genetic resources networks in the Southern Cone, Amazonia, MesoAmerica, Caribbean, Andes, WANA, C. Asia and Transcaucasia, and others; or food trees included in multipurpose tree networks, or in forage networks.

2. Type of network

The basic aim of the network may be characterised in one of three ways:

- Largely for information sharing - e.g. international conferences dealing with lupin, yam bean or persimmon; or other information sharing e.g. bambara groundnut, cucurbits, underutilised wild Mediterranean species,

- Mostly for cooperation between national programmes - e.g. the regional networks, or

- Mostly for inputs of interested individual scientists - e.g. the Working Group of the EUCARPIA Gene Bank Committee.

3. Coordination

The networks may be:

- Well co-ordinated, or the
- Co-ordination is ad hoc, or totally voluntary

The diversity of the 30 or so networks is a reflection of how they have come into being. Others have been created in the recent past and become inactive. Key institutional leaders have been IPGRI, especially for the multicrop genetic resources networks; ICUC and FAO especially for multicrop networks in specific geographic regions, but also CIP for the Andean roots and tubers and AVRDC for some Asian vegetables; and inter-country organisations, such as IICA in Latin America, the Pacific Community or the Commonwealth Science Council. In total, these promoters cover about half of the non-genetic resources based networks.

4.2 Analysis of activities of existing networks

Leaving aside networks mostly dedicated to information exchange, an analysis was carried out of the documented tasks of 21 others.

Table 4.1 Analysis of networks on underutilised crops

Activity	Networks on underutilised crops *% of Networks involved with the activity*	Underutilised crops included in genetic resources networks
Germplasm collection/conservation	90	100
Germplasm exchange/testing	90	65
Germplasm enhancement/use	85	33
Agronomic practices	50	(minor interest)
Training	56	90
Socio-economic studies	5	0
Active participation with NGOs	10	5
Policy dialogues with national/regional organisations	35	100

4.3 Constraints apparent in the current networks

A number of existing networks, without modification, cannot promote the sustainable development ideals of Agenda 21, the stated needs of the FAO Global Plan of Action nor fully the objectives of the Convention on Biological Diversity due to them not being involved in agricultural systems/practices work, due to the lack of socio-economic input to the networks and also due to lack of partnerships with NGOs which can best promote community development.

A more worrying constraint is that a number of networks, and particularly single crop ones, are not very active in policy dialogues with national organisations. This is in part because the participants are often independent scientists rather than government researchers.

New policy dialogues have to be aware that agricultural diversification, as well as the needs for increased breeding and research on priority underutilised species remain the responsibilities of the public sector. The trends towards increasing privatisation of plant breeding will not take great care of underutilised crops because there is little commercial incentive for plant breeding and seed companies.

Much as useful activities have resulted from numerous policy discussions on genetic resources it would be a mistake to mislead national governments that policies for underutilised crops fall mostly within that remit. Already many national programmes on genetic resources are underfunded. Underutilised crops require due attention in national strategic planning, additional to genetic resources strategies, and not necessarily in the same institutional frameworks except for the genetic conservation of the species genepools. Many of the underutilised crops fit policies for sustainable development and policies for commercialisation especially when research on processing leads to added value in markets.

Only one of the networks relates to information on potential domestication of the numerous useful wild (and often "protected" by communities) or semi-domesticated food and other useful plants. In such cases research is needed on propagation and screening of populations for desirable genotypes, activities which have long been part of the comparative advantage of botanic gardens rather than agricultural research centres. This illustrates the need for broad inter-disciplinary policy dialogues at government levels. As is the case for numerous underutilised crops, the useful wild species may well be overexploited and undergoing genetic erosion due to population pressures, lack of sustainable management plans and less than ideal systems of in situ conservation. When nations have clear strategies for land use including food production, agricultural diversification, forestry, rehabilitation of degraded lands etc., many of the wild species will be needed particularly for pasture and forage use, rehabilitation of dry and other stressed environments, and for other purposes such as intercrops, nurse crops, shade plants, windbreaks and many other purposes including protection of watersheds. There are good reasons to focus environmental policy in this direction rather than over-promotion of agricultural production on marginalised and often fragile areas.

For networks to be successful there needs to be strategic focus at the national partner level. Here there are often conflicting views at the decision-making level stemming from lack of synergies between the NARS and the national systems dealing with environment, export promotion, sustainable development and poverty alleviation, indigenous peoples etc. The data gathering for FAO's State of the World's Plant Genetic Resources for Food and Agriculture did not address this particular constraint. Future efforts could pay attention to this need.

Without strategic and integrated policies at the national level, the strategic agenda of any network may not address the needs of the poorest who cannot take responsibility for the natural resources they use if they are insecure tenants, if water rights are not clear or where informal seed sectors do not exist.

Thus many national inputs to current networks are indeed based on individual rather than on integrated policy decisions. As an example, sesame became a priority for Thailand, Nepal, China and Sri Lanka to increase exports, for India and Bangladesh due to shortages of vegetable oil, for Japan to reduce imports and for Republic of Korea to decrease domestic production costs. As a result, countries may join a network for different reasons and the goals of the network must be articulated to encompass many diverse needs. It is also clear that with so many diverse networks on underutilised crops any government decisions at different times on different species will not lead to coherence across numerous underutilised crops.

In reviewing stated priority species of a number of countries and regions, attempts to match them with existing networking arrangements leave huge gaps. One outstanding one is where species are underutilised in a particular country but well utilised elsewhere. The country wishing to use it further often has no critical mass to initiate new research. Technology transfer, rather than networking, would be more logical. Examples would include garlic or apricot in Pakistan, or walnut in Central Asian Republics.

It is also noticeable that few international agricultural research centre efforts include underutilised crops. Apart from IPGRI, with emphasis on genetic resources, ICARDA and ICRISAT participate in a *Lathyrus* network, ICRAF in a food tree network in Sub-Saharan Africa, and IITA in a bambara groundnut network. CIP organises the Andean root and tuber network and participates with CIAT and IPGRI in an Andean genetic resources network. Other centres work on specific underutilised crops e.g. ICRISAT on finger millet and AVRDC on okra and cucurbits in Asia.

A final constraint which has become apparent is that even within networking arrangements, exchange of germplasm, even for research, is often very limited, and when network participants express the need and the wish to use nationally-approved procedures. This is because of the provisions of the Convention on Biological Diversity that requires access through prior informed consent on mutual terms. There has been a marked decrease in germplasm exchanges South-South in recent years. From October 1998, the FAO Commission on Genetic Resources has been discussing the possibilities of listing underutilised crops as part of a multilateral system of availability and this is an ongoing discussion.

4.4 Regional versus commodity networks

Current international policy related to agricultural research is in general favourable to networking e.g. to implement the FAO Global Plan of Action, to foster innovative research partnerships, and overall to mobilise the various stakeholders comprising the global agricultural research community in efforts to increase food security, alleviate poverty and promote sustainable use of natural resources. The Global Forum on Agricultural Research (GFAR) which brings together NARS, CGIAR, advanced research institutes, the private sector and NGOs as well as other stakeholders has stated in a recent shared vision that global/regional research networks on important crops (based on commodity-chain approach) and new institutional/organisational approaches to research are ways ahead. This strengthens the concept of networking for underutilised crops.

In reviewing the current networks it is apparent that the global commodity approach is only viable when there are sufficient specialists on the particular crop. Comparisons or criticisms would be invidious; but it is sufficient to note that some can be successful, others not; and the less known the underutilised crop is and the fewer the researchers involved the less likely it is for a network to succeed.

This means there is a strong case for regional or sub-regional networks that can take on the responsibilities for one or more underutilised commodity groups such as fruits, vegetables, or whatever priorities the partners set. These would be of moderate size, thus being conducive to developing the scope of work, the practical workplans and agreement on sharing research responsibilities.

Nonetheless for regional or sub-regional networks to have a sure foundation the national participants need clearly-formulated national interest, and policy to back their partnerships. Since the regional or sub-regional network will deal with a mix of species the danger that one member, where one crop is of secondary importance, may lose interest is overcome because the mix of species will be determined so that all partner activities are strengthened. The structure and governance has to be such that the network can collectively change its priorities and workplans depending on successes or failures and this should in no way detract from the overall goals of enhancing NARS and the effectiveness of shared research. With this type of objective such a network will more readily attract funding.

4.5 Rethinking networks

Comments made above, and analysis of the current situation, would strongly support the suggestion that a number of existing networks need to be re-organised. For instance, where a regional network exists, activities on an underutilised crop based on a commodity approach and underfunded, could be taken on as a priority of the regional network.

Where regional networks do not exist, and where there are total gaps in developing priority underutilised crops, dialogue should be initiated to plan future action. International organisations can be helpful in identifying the major gaps and initiating dialogue with the stakeholders in this respect.

5 DISCUSSION AND PROPOSED STRATEGY

Strategy development and appropriate policies are limited to a large extent by a lack of documentation on underutilised crops. In particular there is a limited knowledge on on-farm conservation and use of particular species especially in relation to what is considered traditional. Frequently this is only viewed in relation to poor or subsistence farmers. Yet government strategies and policies for food security should take into account the diversity in homestead gardens, mixed crop smallholdings and small plots adjacent to fields. Local systems for plant supplies, or seed flows, keep these agroecosystems dynamic and even permit sophisticated actions by farmers such as the small plots cultivated for drought years and the food gathered from semidomesticated plants.

Taking into account agroecosystem diversity the NARS needs to take a dual approach: considering some underutilised crops as commodities and at the same time considering an agroecosystem approach. It is well to recall lessons of the past where agricultural modernisation

and increased production was often through changed agricultural practices long before the input from plant breeding. In any particular case, a logical framework needs to be defined for research input otherwise the research effort will be spread too thinly. For instance the strategy might define the adaptive potentialities of local varieties and research be put in place to use these to the maximum. This requires a participatory approach because breeding for target agroecosystems requires knowledge of the physical variables and also the socio-economic background.

Decisions to introduce new crops into the traditional agricultural areas also requires adaptive research and assessment of suitable agricultural practices. The oft-quoted example of the failure of the introduction of new crops to southern France in the eighteenth century provides a lesson. The crops were introduced into an agriculture that had hardly changed from Roman times and low yields resulted with decades of poor harvests.

Changes over time in the patterns of traditional agriculture are obvious and any current documentation of agroecosystems with rich diversity is only meaningful in relation to managing traditional agriculture better and assuring the continued well-being of the communities it supports. Substitution of one crop by another of identical or equivalent use e.g. small millets replaced by maize or *Lagenaria siceraria* replaced by *Cucurbita pepo* is normal and is guided by farmer preference. Changes which cannot be guided by farmer preferences are those caused by economic or practical factors. For instance in the Mediterranean, fenugreek, *Vicia ervilia* and *Vicia monanthas*, part of the traditional agriculture, have fallen to very low levels over the past 60 years. They were largely used for animal feed but two factors caused their decline: first they cannot easily be harvested mechanically, and second, wheat was easier to use in place of them.

Understanding and using to positive advantage these patterns of change is a complex issue. Rightfully, international attention has focused on the need to conserve and better use the genetic diversity in traditional agroecosystems, but support at the national, regional and even local level has rarely been carefully thought out; support in terms of seed supplies, plant conservation, availability of new germplasm etc. For instance it is logical that smallholders in Latin America can have available good planting stock of walnut (*Juglans regia*), but this can accelerate the severe genetic erosion of the genepool of indigenous *Juglans* species, especially *J. nigra* and even *Carya illinoensis*. Such genetic erosion will continue until practices are well-articulated and take into account the socio-economic well being of farmers and communities, and agricultural policy linked to forestry and export policy which currently provides huge incentives to local people to fell indigenous trees since there is great demand for veneer for the furniture industry.

Information alone on the species being used, on the people involved in the management and use and on their ecological and human contexts is insufficient. Policies have to address adaptive management in response to change and to adjust incentives and regulations including impact on social harmony; a large agenda with numerous variations in land/resource rights and ownership, and in the human system ranging from producers, consumers to entrepreneurs and local and government controllers/managers.

These comments illustrate why it has proved difficult to wed needs for plant genetic resources collecting, evaluation and conservation with planting material supply systems and research on

production in the areas of traditional agriculture. Strategy urgently needs to be developed in this area, and not least by international organisations. In practice, what is happening at present is the continuation of the ethnobotanical listings, which - valuable as they are - are limited in application. Table 5.1 shows a summary of such listings from two very diverse areas. The sheer number of species can be bewildering to planners let alone scientists.

The value of ethnobotanical data cannot be overstressed. It is more how such data can be gathered and used by researchers that poses problems. For instance, Pearce (1996) points out that frequently the data are gathered without a full understanding and study of the community concerned. In many cases botanists are overly concerned with collecting and identifying the plants, in other cases data gathering is based on attempts to justify traditional life-styles or cultural identity and data can lack the objectivesness necessary in planning research.

A further consideration relating to traditional agroecosystems is that frequently they are inadequate for current needs. This has great implications on the need to conserve diversity in situ in many of these agroecosystems and the urgent needs to change them. For instance in Bangladesh per capita availability of fruits from homestead gardens is low and there is a high prevalence of malnutrition in the country. Also due to limited supply of cultivated land field orchards face serious competition for land from crops such as rice and wheat and urbanisation, making it unlikely that the field orchard area will grow substantially to meet increased demand for fruits. The clear policy has to be to upgrade and change the homestead production (Karim & Rahman, 1993). In listing constraints in homestead farming 72% of farmers recorded lack of planting material and 82% lack of knowledge as well as other constraints such as lack of capital. Governments assess situations and develop policies and these vary from country to country. For instance the example of Bangladesh homestead gardens is not applicable to other tropical countries in S and SE Asia. Malaysian policy is to develop commercial fruit production through the development of nuclear fruit estates and rehabilitation of unorganised and dispersed smallholders through group farming projects and mini-estates (Tamin, 1993). Both policies will lead to major changes in the traditional agroecosystems.

Table 5.1 Summary of diversity in home gardens in Ethiopia (from Zemede Asfaw and Ayele Nigatu, 1995) and Vietnam (from IPGRI report)

	Number of crop species*	**Number of which are underutilised crops**
Ethiopia		
Fruits	35	7
Vegetables	31	6
Roots and tubers	12	3
Pulses	14	6
Cereals	6	1

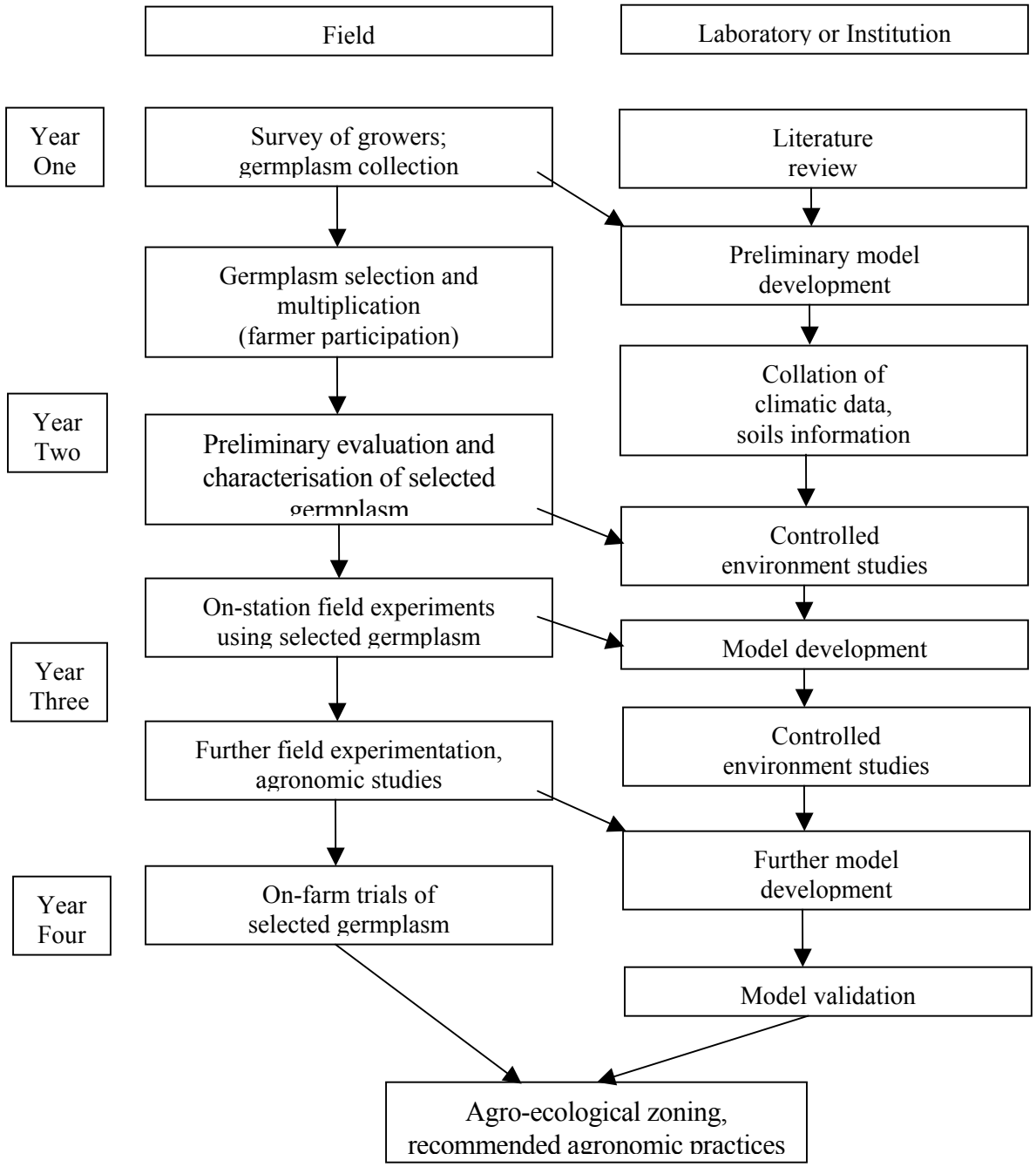
	Number of crop species*	Number in more than 10% of plots
Vietnam		
Fruits	69	10
Vegetables/salad	142	23
Roots and tubers	26	5
Medicinals	157	
Ornamentals	198	
Spice	60	
Others (green manure etc.)	45	
Timber	49	

* Note: figures include a number of non-indigenous introduced species that have become traditional over the past 250 years.

5.1 Developing clearer strategy

Focus on priority underutilised crops in traditional agricultural areas and development of procedures for assessing the sustainability of their use - tied to focused research to evaluate the potential and ecological requirements - could go a long way in advancing knowledge and avoid the limited and piecemeal research. In order to help strategy development at the national level it is recommended that a small methodology workshop be convened by ICUC, FAO and IPGRI to develop guidelines in this area and that funding should be sought to test the guidelines in the context of already- agreed priority underutilised crops. This testing could be within the framework of the active coordinated networks and with participation from suitable experts who have developed the thinking in this area e.g. through the EU Project T53+CT920121 (Life Sciences and Technologies for Developing Countries); see EU, 1998. Methodology will include assessment of local know-how, socio-economic background, policy framework, development of a scientific and analytical framework to establish the agro-ecological potential (Fig. 5.1). It should be noted that a 4-year time frame is minimum and for long-lived perennials may be much longer. Even so trials will take a number of years so the time frame in Fig 5.1 is less important than the methodology.

Figure 5.1 **An approach to assess the yield potential and ecological requirements of any underutilised crop** (source: report project number TS3*CT920121)



5.2 The need for information

Slow progress in developing underutilised crops results from a number of constraints outlined by Haq (1995) and summarised below. They include lack of:

- available information on production, consumption and utilisation,
- available genetic materials for testing,
- coordination of stakeholders from producers to researchers and users,
- coordination of project formulation at national, regional and international levels,
- prioritisation for genetic resources and sustainable utilisation,
- marketing and transport facilities,
- improved genetic materials,
- improved agronomic practices,
- training,
- promotion of specific underutilised crops, and
- government policies, initiatives and incentives to producers.

At one time it was felt that compendia of information crop by crop would provide useful starting points for institutions taking up underutilised crop research. The efforts in recent years have produced a number of valuable compendia but there is no evidence to show that they have stimulated major new research efforts. In the future, almost certainly, information will need to be in computerised documentation systems, and constantly adding to these will be a major responsibility for the global community. It has been largely ignored to the present, and has not attracted funding.

It is recommended that in the context of the Global Plan of Action, FAO in collaboration with ICUC, initiates such a documentation system and mobilises funding for it.

It should be noted that many misunderstandings are apparent in terms of recent discussions on sovereign property of plant resources. Better information would go a long way in dispelling some misconceptions, and also inactivity stemming from them.

It is often widely misundertood that traditional agriculture and production of underutilised crops to mitigate emergency situations is based on rich indigenous diversity. In fact when national priorities are defined to enhance research on underutilised crops many individual crops are exotic introductions. Mal (1995) in listing such priorities for India includes 8 first priority crops, 10 second priority crops and 4 third priority crops. Of these, 3, 3 and 4 respectively are introductions.

Similarly, the MESFIN Network on fruits of the Mediterranean focuses on 16 crops or crop groups (Galan-Sauco, 1998) of which only 2 are indigenous to the region, although many have shown secondary diversity in the area. Most of these fruits are of major interest but several are underutilised.

5.3 Enhancing research priority setting and cooperation

Research planning and priority setting are closely linked and determined by government policies. Earlier sections of this report have shown that clear government policies in relation to underutilised crops are rare.

In effect what is needed is appropriate policies in association with supportive institutions of the NARS to produce targeted improved technology which aims at sustainability, adequate recognition of women and poverty alleviation. Reaching decisions at the government level on priorities and modalities for action is only logical using mechanisms that are participatory:

(i) assessment of knowledge on resource use systems developed by farming communities
(ii) recognition of urgent social and economic needs
(iii) matching existing resources to enhanced production of commodities and products, and
(iv) recognising there are often eco-regional complementarities with neighbouring countries.

In recent years it has become far more widely recognised that research priority setting and strategy development at the national level needs to involve all actors within diverse Ministries. This means that priority setting for underutilised crops requires not only the broad NARS (research institutes, universities, NGOs, user groups, private sector etc.) but also input from agencies involved with environment, Agenda 21, and others.

There is a need for international organisations to facilitate national policy development. This would also greatly enhance regional and subregional cooperation. The Asia Pacific Association of Agricultural Research Institutes (APAARI) met in 1996 and discussed subregional priorities. Discussions on underutilised crops led to different focuses: need to prioritise and integrate research on non conventional or underutilised species (S. Asia), diversification of agriculture and low input sustainable development (E. Asia), or specific focus on enhanced production and commercialisation of fruits and other underutilised crops (S.E. Asia).

Since subgroupings for research recognise traditional linkages and common and diverse national, economic, social and political differences the research groupings will only be successful when these have been built on a series of the national policies.

Due to the lack of critical mass of researchers on underutilised crops, intercountry cooperation is likely to be needed for quite some time.

It is recommended that in the next 2-3 years, ICUC, GFAR, FAO and CGIAR should promote national policy development and regional cooperation for underutilised crops. This could be done through the subregional discussions of GFAR.

5.4 Keeping networks under review

When discussing networks it was apparent that there are major gaps - especially in how to cope with the generally agreed priority species - and the networks are very diverse in structure.

A degree of re-organisation of networks would be logical in the next few years. This will become more apparent as national policy formulation becomes clearer. Mobilisation of funding for network support appear to be favouring a regional, multi-species approach. Some crops currently dealt with by a commodity network might well have to be joined to other networks. This will also take care of some specific commodities, the networking for which has never attracted funding.

5.5 Mobilising support for highly focused activities

International organisations, and indeed this report, highlight the continuing need for project funding for strategic action to support the emergence of a global system for enhanced production of underutilised crops.

It is recommended:

1 that bilateral donors should consider twinning arrangements for R & D of high priority species;

2 that better South-South collaboration be considered especially using those few countries with strong national programmes on underutilised crops;

3 that to build capacity, a major training programme should be developed and implemented internationally and

4 that a consortium approach be considered for the support of the networks.

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