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Item 3 of the Provisional Agenda

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

INTERGOVERNMENTAL TECHNICAL WORKING GROUP ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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DRAFT SECOND REPORT ON THE STATE OF THE WORLD'S PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture

Summary

This report describes the current status of conservation and use of plant genetic resources for food and agriculture (PGRFA) throughout the world. It is based on 106 country reports, two regional syntheses, several thematic reports and published literature. It describes changes that have taken place since the first State of the World report was prepared in 1996 and major continuing gaps and needs. The structure follows that of the first report with an additional chapter on the contribution of PGRFA to food security and sustainable agricultural development.

1 The state of diversity

Trends in the conservation and use of PGRFA are set against the effects of globalization, increased food and energy prices, climate change, growth in markets for 'diversity rich' food and debate over genetically modified crops.

Ex situ collections have increased by 20% since 1996, to reach 7.4 million accessions, of which some 25% are believed to be unique and distinct. While the number of accessions of minor crops and crop wild relatives has increased, these categories are still generally under-represented. The number of species in national collections has increased on average by 57%.

With the development of new techniques, the amount of molecular data available on genetic diversity has increased dramatically, leading to an improved understanding of issues such as domestication, genetic erosion and genetic vulnerability. The introduction of modern varieties of staple crops appears to have resulted in an overall decrease in genetic diversity on farm, although within the released varieties themselves the data are inconsistent and no overall narrowing of the genetic base can be discerned. The situation regarding genetic erosion in landraces and crop wild relatives is equally complex. While many recent studies have confirmed that diversity in farmers' fields and protected areas has eroded, this is not universally the case.

Many country reports expressed continuing concern over the extent of genetic vulnerability and the need for a greater deployment of diversity. However, better techniques and indicators are needed for monitoring genetic diversity and to establish baselines and monitoring trends.

There is evidence of growing public awareness of the importance of genetic diversity, both to so as to meet increasing demands for greater dietary diversity, and to meet future production challenges. The increased environmental variability that is expected to result from climate change implies that in the future, farmers and plant breeders will need to be able to access an even wider range of PGRFA than today.

2 The state of *in situ* management

Since the first SoW report was published, a large number of surveys and inventories have been carried out, in many different countries, both in natural and agricultural ecosystems. As a result, there is increased awareness of the importance and value of crop wild relatives and of the need to conserve them *in situ*. The number and coverage of protected areas has expanded by approximately 30% over the past decade and this has indirectly led to a greater protection of crop wild relatives. However, relatively little progress has been achieved in conserving wild PGRFA outside of protected areas or in developing sustainable management techniques for plants harvested from the wild.

Significant progress has been made in the development of tools and techniques to assess and monitor PGRFA within agricultural production systems. Countries now report a greater understanding of the amount and distribution of genetic diversity on farm, as well as the value of local seed systems in maintaining such diversity. More attention is being paid to increasing genetic diversity within production systems as a way to reduce risk, particularly in the light of changes in climate, pests and diseases. The number of on farm management projects carried out with the participation of local stakeholders has increased and new legal mechanisms have been put in place in several countries to enable farmers to market genetically diverse varieties or geographically identified products.

3 The state of e*x situ* conservation

Since the publication of the first SoW report, more than 1.4 million accessions have been added to *ex situ* collections, the large majority of which are in the form of seeds. At least 220,000 of these are the result of new collecting missions. Fewer countries account for a larger percentage of the total world *ex situ* germplasm holdings than was the case in 1996.

While many major crops are well, even over-duplicated, many important collections are inadequately so and hence potentially at risk. For several staple crops, such as wheat and rice, a large part of the genetic diversity is currently represented in collections. However, for many others, considerable gaps remain. Interest in collecting crop wild relatives, landraces and neglected and underused species is growing as land-use systems change and environmental concerns increase.

Many countries still lack adequate facilities, funds or management systems to meet their *ex situ* conservation needs and obligations, and as a result a number of collections are at risk. Many require regeneration although it has not been possible to establish the extent to which this remains a global problem. In spite of advances in documentation and characterization, it is inadequate for many collections, and where information does exist it can often be difficult to access.

The creation of the Global Crop Diversity Trust (GCDT) and the Svalbard Global Seed Vault (SGSV) both represent major achievements since the first SoW report was published and the world's PGRFA is undoubtedly more secure as a result. However, while seed collections are larger and more secure overall, the situation has not progressed to the same extent in the case of vegetatively propagated species.

4 The state of use

The economic and policy conditions under which agricultural takes place have changed considerably since the first SoW report was published. Issues of sustainability, food security and nutrition, for example, have become more prominent. Whereas it is still difficult to assess the overall extent and nature of utilization of PGRFA, its adoption as a basis for improving crop production seems to have changed little. However, there appears to have been an increase in its use PGRFA for cultural and educational purposes.

Several important new initiatives and legal instruments have been developed to promote the use of PGRFA. The Global Partnership Initiative for Plant Breeding Capacity Building (GIPB), for example, aims to enhance the sustainable use of PGRFA in developing countries through helping build capacity in plant breeding and seed systems. The new GCDT, and Generation and Harvest Plus Challenge Programs of the Consultative Group on International Agricultural Research (CGIAR) all support the increased characterization, evaluation and improvement of germplasm.

Several issues in PGRFA use have become more prominent and new ones have emerged. Genomics, proteomics, bioinformatics and climate change were all absent from the first SoW report and greater importance is now also given to sustainable agriculture, biofuel and bioenergy crops, human health and dietary diversity. Progress in research and development on neglected and under-utilized species, as recommended in the first SoW report, is difficult to gauge.

5 The state of national programmes, training needs and legislation

The Global Plant of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (GPA) promotes the building of strong national PGRFA programmes to underpin sustainable agricultural development. Notwithstanding problems of defining and classifying national programmes, overall it appears that progress has been made since the publication of the first SoW report. Sixty percent of countries that submitted a country report claimed to have some form of national programme, up from about fifty percent in 1996.

National programmes very considerably, in terms of their size, structure, organization, institutional composition and objectives. Twenty-seven percent of countries report having a formal centralized national programme; ten percent a formal, sectorial system with national coordination; thirty percent a formal sectorial system with no national coordination; and only three percent have some form of national coordination mechanism. The overall percentage of reporting countries that possess a strong central coordinating mechanism had fallen since 1996. More attention is needed to this and to strengthening links between those who conserve and use, and between the public, private and informal sectors.

While there is evidence that funding levels have increased in many countries, for others the reverse is true. There is a larger number of new donors now supporting activities in PGRFA than was the case in 1996.

There has been an expansion in education and training opportunities over the past decade. However more capacity is needed, especially to: upgrade skills in biotechnology, bioinformatics and other hi-tech areas; train senior managers and policymakers in legal and policy issues; and train development workers, Non-governmental Organizations (NGOs) and the like in the on farm management and marketing of traditional crops and varieties.

Good progress has also been made over the past decade in the enactment of national legislation and in putting in place policies and regulations on the conservation and use of PGRFA, including areas such as access and benefit sharing, farmers' rights, seed regulations, phytosanitation, intellectual property and biosafety.

6 The state of regional and international collaboration

Given the high level of interdependence among countries with respect to the conservation and use of PGRFA, it is imperative that there be strong and extensive international cooperation. Considerable progress has been made in this since the first SoW report was published. A number of new regional networks on PGRFA, have been established, and others have become stronger and more active. Three new regional networks specifically addressing the issue of seed production have been established in Africa.

International collaboration is strongly promoted by the new International Treaty on PGRFA (ITPGRFA), for which FAO provides the Secretariat. FAO has further strengthened its activities in PGRFA since the first SoW report, for example through establishing GIPB in 2006. The International Centres of the CGIAR concluded agreements with FAO in 2006, acting on behalf of the Governing Body of the ITPGRFA, bringing their collections within the ITPGRFA's multilateral system of access and benefit sharing. The CGIAR itself is undergoing significant reform.

There have also been many other new international initiatives, including the establishment of the International Network for Bamboo and Rattan (INBAR) in 1997, International Center for Biosaline Agriculture (ICBA) in 1999, Central Asia and the Caucasus Association of Agricultural Research Institution (CACAARI) and Global Forum on Agricultural Organization (GFAR) in 2000, Forum for Agricultural Research in Africa (FARA) in 2002, Global Cacao Genetic Resources Network (CacaoNet) in 2006 and Crops for the Future and the SGSV in 2008. All have significant activities in PGRFA. In the area of funding, several new foundations now support international activities in PGRFA. A special fund to support agricultural research in Latin America (Regional Fund for Agricultural Technology-FONTAGRO) was set up in 1998, and the GCDT was established in 2004.

7 Access to plant genetic resources, the sharing of benefits derived from their use and the realization of farmers' rights

The international and national legal and policy framework for Access and Benefit-sharing (ABS) has changed substantially since the publication of the first SoW report. Negotiations under the Convention on Biological Diversity (CBD) to develop an international regime on ABS are scheduled to be finalized in 2010. However, many issues remain to be settled, including the legal status of the regime. Discussions on matters related to ABS are also taking place in other fora such as the Trade-related Aspects of Intellectual Property Rights (TRIPS) Council and Wold Intellectual Property Organization (WIPO).

Perhaps the most far-reaching development has been the entry into force in 2004 of the ITPGRFA. The ITPGRFA establishes a Multilateral System of access and benefit-sharing that facilitates access to plant genetic resources of the most important crops for food security, on the basis of a Standard Material Transfer Agreement. Some 120 countries are party to the ITPGRFA.

While there has been an increase in the number of laws and policies on ABS already enacted at the national level, many countries have expressed a desire for assistance in confronting the complex legal and technical issues involved in drawing up new legislation. So far there are few models that can be emulated and several countries are experimenting with new ways of protecting and rewarding traditional knowledge and realizing Farmers' Rights.

8 The contribution of PGRFA to food security and sustainable agricultural development.

PGRFA is the foundation of global agriculture, underpinning its ability to adapt to changing circumstances and meet future challenges. Food insecurity continues to be widespread; FAO estimates that there are 1.02 billion chronically hungry people in the world, most of whom live in rural areas of developing countries and depend on agriculture for a large part of their livelihoods. To meet increasing global demand for agricultural produce, two main approaches are needed: a) maintaining productivity growth in high-productivity ‘breadbaskets’, and b) increasing productivity on marginal lands. These approaches should result in both greater access to food by the rural and urban poor, and in helping to increase the income of resource-poor farmers. However, it is essential for both approaches that negative impacts on human health and the environment be avoided.

The genetic improvement of both major and minor crops is central to achieving these goals as well as for addressing new challenges such as those posed by climate change. It is particularly important, when breeding crops for resource-poor farmers, that their situation and perspectives be taken into account. Many cultivate crops for both subsistence and the market, and are concerned not only with maximizing yield but also minimizing risk and meeting multiple objectives. Women farmers have different needs and face different circumstances than men and are often the custodians of traditional crops and the knowledge thereof. The drivers of, and constraints to, adoption of new varieties by the intended target population must be taken into account in plant breeding efforts.

The contribution of PGRFA to increased food security and sustainable agricultural development could be enhanced through developing better indicators for monitoring and evaluating the impact of PGRFA; strengthening farmers’ access to a diverse range of varieties; better integrating the conservation and use of PGRFA and the efforts of the public and private sectors; employing more decentralized, participatory and gender-sensitive plant-breeding approaches; breeding varieties which contribute to more sustainable farming systems; and strengthening resource–poor farmers’ links to both input and output markets.

Chapter 1

The state of diversity

1.1 Introduction

Chapter One of the first SoW report described the nature, extent and origin of genetic diversity between and within plant species, the interdependence among countries with respect to their need for access to resources from others, and the value of this diversity, especially to small-scale farmers. This chapter expands and updates the information provided in the first SoW report and introduces a number of new elements. It seeks to place plant genetic resources for food and agriculture (PGRFA) in the wider context of changing food production and consumption patterns and it describes the state of diversity in farmers' fields, *ex situ* collections and protected and unprotected natural areas across the globe. It provides an updated review of the status of genetic vulnerability and of the interdependence among countries and regions in the conservation and use of PGRFA. New information is provided on indicators of genetic diversity and on assessment techniques and the chapter ends with summary of major changes that have taken place since 1996 as well as gaps and needs for the future.

Since the first SoW report was published in 1996, certain trends have become more visible and new ones have emerged. Globalization has had a growing impact, food and energy prices have risen, organic foods have become increasingly popular and economically attractive, and the cultivation of genetically modified crops has caused heated debate. Food +security continues to be a worldwide concern and is likely to remain so for the foreseeable future as the world population continues to expand, as resources become scarcer and as pressures mount to develop productive land for alternative uses. Climate change is now widely considered to be unavoidable. The development of new varieties and cropping systems adapted to the new conditions will be crucial in order to limit yield losses in some regions and to take advantage of changed conditions in others (see also Chapter 4.9.5).[1,2,3] Many economists believe that food prices will remain above the historically low levels that prevailed for much of the last decade and continuing increases in productivity, especially in developing countries, will be essential to achieve global food security. However, in many areas of the world, crop yields have started to plateau or even decline as a result of environmental degradation, increasing water and energy shortages and a lack of targeted investments in research and infrastructure (see Chapter 8).[4] At the same time, investment in agricultural research, in both developed and developing countries, has continued to show high economic rates of return, not least through the development and deployment of new varieties.

1.2 Diversity within and between plant species

Only a few of the country reports contain data that allow a direct and quantitative comparison of changes in the status of diversity within and between crops over the period since 1996. Furthermore, where quantitative comparisons have been included, these mainly concern the number of released varieties or changes in crop acreages, both of which are only very indirect indicators of change in genetic diversity in farmers' fields. However, it seems clear that on farm management initiatives have expanded in the past decade, as the scientific basis of such work has become better understood and appropriate methodologies established. The linkages between on farm management of PGRFA and *ex situ* conservation and use have also strengthened, although in many ways the two sectors remain compartmentalized. The continued growth of *ex situ* collections and the increased inclusion of threatened genetic diversity within them is a positive trend, although regeneration and duplication continue to be areas of concern. No quantitative data were provided on the changing status of crop wild relatives (CWR), but several countries reported on specific measures that had been taken to promote their conservation. Finally, there is evidence that public awareness of the importance of crop diversity, especially of formerly neglected and under-utilized species such as traditional vegetables and fruits, is growing both in developing and developed countries.

1.2.1 Status of on farm managed diversity

Throughout most of the developed world, industrialized production now supplies the majority of food. Modern breeding has resulted in crop varieties that meet the requirements of high-input systems and strict market standards (although there is also breeding work aimed at low-input and organic agriculture). Strong consumer demand for cheap food of uniform and predictable quality has resulted in a focus on cost-efficient production methods. As a result, over the last decade multi-national food companies have gained further influence and much of the food consumed in industrialized countries is now produced beyond their national borders.[5] This pattern of food production and consumption is also spreading to many developing countries, especially in South America and parts of Asia,[6] as incomes rise in those regions. However, in spite of this trend, a substantial portion of the food consumed in the developing world is still produced with few, if any, external chemical inputs and is sold locally. Such farming systems generally rely heavily on diverse crops and varieties, and in many cases on a high level of genetic diversity within local varieties. This represents a traditional and widespread strategy for increasing food security and reducing the risks that result from the vagaries of markets, weather, pests or diseases. Through the continuing shift from subsistence to commercial agriculture, much of the diversity that still exists within these traditional systems remains under threat.

Over the last decade, promoting and supporting the on farm management of genetic resources, whether in farmers' fields, home gardens, orchards or other cultivated areas of high diversity, has become firmly established as a key component of crop conservation strategies, as methodologies and approaches have been scientifically documented and their effects monitored (see Chapter 2).

Participatory plant breeding (PPB) has become more widely adopted as an approach to the management of diversity on farm, with an objective of both developing improved cultivars as well as conserving adaptive and other traits of local importance. It provides a particularly effective linkage to both *ex situ* conservation and use. More information on the status of PPB is given in Chapter 4.6.2.

The maintenance of genetic diversity within local production systems also helps to conserve local knowledge. With the disappearance of traditional lifestyles and languages across the globe, a large amount of knowledge about traditional crops and varieties is being lost and with it much of the value of the genetic resources themselves, justifying greater attention to the on farm management of PGRFA.

1.2.2 Status of diversity in ex situ collections

Chapter 3 shows that the total number of accessions conserved *ex situ* world-wide has increased by approximately 20% (1.4 million) since 1996, reaching 7.4 million. It is estimated, however, that less than 30% of this total are distinct accessions (1.9 - 2.2 million). During the same period, new collecting accounted for about 220,000 accessions. Major trends can be inferred by comparing the current state of diversity of a set of well documented *ex situ* collections with that pertaining at the time of the first SoW report. To that end, data on 12 collections held by the centres of the Consultative Group on International Agricultural Research (CGIAR) and the Asian Vegetable Research and Development Center (AVRDC), and 15 collections held in national agricultural research systems have been analyzed (see Tables 1.1 and 1.2 respectively). These collections account for a substantial proportion of total global *ex situ* resources.

Overall, these e*x situ* collections have grown considerably in size. Between 1995 and 2008, the combined international collections maintained by the CGIAR and AVRDC increased by 18% and national collections by 26%. However, how much of this is completely new material and how much represents the acquisition of materials already present in other genebanks is unknown.

Although the prevailing opinion in 1995 was that the coverage of the diversity of the major staple crops[7] within the CGIAR collections was fairly comprehensive,[8] many collections have grown since then as gaps in the geographic coverage of the collections have been identified and filled and additional samples of CWR added. Adjustments to the numbers have also been made as a result of improved documentation and management. In addition, several of the CGIAR genebanks have taken on responsibility for collections of materials with special genetic characteristics and orphan collections provided by others. Although the major growth in the CGIAR collections has been for species that were already present before 1995, a considerable number of new species have also been added.

In the case of the national collections analyzed, there has been a particularly large increase in the number of species and accessions of non-staple crops and CWR – although these are still generally under-represented in collections.[9] The increase in species coverage has been dramatic; 57% on average since 1995. However, there are large differences among countries: some collections are still being built and have shown large increases (e.g. Brazil, Ecuador and India), others are stable or in a consolidation phase (e.g. Germany, Russian Federation). Even greater variability is to be expected across the full range of genebanks worldwide. From 1995 to 2008, the average number of accessions per species in the national collections analyzed dropped from 102 to 82.

The standard of conservation of the CGIAR collections has advanced over the past decade, largely as a result of additional financial support from the World Bank. Regeneration backlogs have decreased very substantially and no significant genetic erosion is reported. However, in the case of the national genebanks a more complex picture emerges. A recent series of studies by the Global Crop Diversity Trust (GCDT) covering 20 major crops[10] reports large regeneration backlogs in a considerable number of national collections. Other concerns include:

- Neglected and under-utilized species remain generally under-represented in collections. The situation may become even more serious if there is a greater shift in the focus of attention to crops that are included within the Multilateral System of Access and Benefit Sharing under the International Treaty on Plant Genetic Resources for Food and agriculture (ITPGRFA);

- The number of individuals (seeds, tissues, tubers, plants, etc.) conserved per accession is frequently below the optimum for maintaining heterogeneous populations;

- CWR are generally expensive to maintain and remain under-represented in *ex situ* collections, a situation that is unlikely to change unless considerably more resources are provided for the task.

Table 1.1 Comparison between the collections maintained by CGIAR and AVRDC in 1995 and 2008[a]

Centre	1995 (No)			2008 (No)			Change (%)		
	Genera	Species	Accessions	Genera	Species	Accessions	Genera	Species	Accessions
AVRDC	63	209	43,205	160	403	56,522	154	93	31
CIAT	161	906	58,667	129	872	64,466	-20	-4	10
CIMMYT	12	47	136,259	12	48	173,571	0	2	27
CIP	9	175	13,418	11	250	15,046	22	43	12
ICARDA	34	444	109,223	86	570	132,793	153	28	22
ICRAF	3	4	1,005	3	6	1,785	0	50	78
ICRISAT	16	164	113,143	16	180	118,882	0	10	5
IITA	72	155	36,947	72	158	27,596	0	2	-25
ILRI	358	1,359	13,470	388	1,746	18,763	8	28	39
INIBAP/Bioversity	2	21	1,050	2	23	1,207	0	10	15
IRRI	11	37	83,485	11	39	109,161	0	5	31
WARDA	1	5	17,440	1	6	21,527	0	20	23
Total	**494**	**2,813**	**627,312**	**612**	**3,446**	**741,319**	**24**	**23**	**18**

[a] Sources: Individual genebanks; SINGER Website 2008; WIEWS 1996. 1995 data for IITA and ICRAF are from Singer CD 1997. Undetermined genera were not counted

Table1.2 Comparison between the collections maintained by selected national genebanks in 1995 and 2008 [a]

Country	**Genebank**	**1995**			**2008**			**Change (%)**		
		Genera[b]	**Species**	**Accessions**	**Genera**	**Species**	**Accessions**	**Genera**	**Species**	**Accessions**
Brazil	CENARGEN	136	312	40,514	212	670	107,246	56	115	165
Canada	PGRC	237	1,028	100,522	257	1,166	106,280	8	13	6
China	ICGR	---	---	358,963	---	---	391,919	---	---	9
Czech Republic	RICP	34	96	14,495	30	175	15,421	-12	82	6
Ecuador	INIAP-DENAREF	207	499	10,835	272	662	17,830	31	33	65
Ethiopia	IBC	71	74	46,322	151	324	67,554	113	338	46
Germany	IPK Gatersleben[c]	633	2,513	147,436	801	3,049	148,128	27	21	0
Hungary	ABI	238	742	37,969	294	915	45,321	24	23	19
India	NBPGR	73	177	154,533	723	1,495	366,333	890	745	137
Japan	NIAS	---	---	20,2581	341	1,409	243,463	---	---	20
Kenya	KARI-NGBK	140	291	35,017	855	2,350	48,777	511	708	39
Nordic Countries	NGB[d]	88	188	24,241	129	319	28,007	47	70	16
Russia	VIR	262	1,840	328,727	256	2,025	322,238	-2	10	-2
The Netherlands	CGN	30	147	17,349	36	311	24,076	20	112	39
USA	NPGS[e]	1,582	8,474	411,246	2128	11,815	508,994	35	39	24
Average		**287**	**1,260**	**128,717**	**463**	**1,906**	**162,772**	**61**	**51**	**26**

a. Genebanks selected according to the size of the collections and availability of data. Figures represent accession numbers. Data sources are as follows: Brazil genebank manager; Canada genebank manager; China, 1995 and 2008 Country report; Czech Republic, WIEWS 1996 and EURSICO 2008; Ethiopia WIEWS 1996 and National Information Sharing Mechanism on PGRFA (2007); Ecuador, genebank dataset, WIEWS 1996 and National Information Sharing Mechanism on PGRFA (2008); Germany, WIEWS 1996, EURISCO 2008, Country reports 1995 and 2007; Hungary, genebank manager; India, genebank manager; Kenya WIEWS 1996 and National Information Sharing Mechanism on PGRFA (2008); Nordic Countries, genebank dataset; Russia, genebank manager; The Netherlands, genebank manager; USA USDA GRIN dataset.

b) Taxonomic systems vary among genebanks, and may have changed over time. Hybrids and unidentified species are included.
c) 1995 data refer to germplasm holdings from IPK and its two external branches in Gross-Luesewitz and Malchow, plus those from PGRC in Braunschweig, as this was shut down and the biggest part of its collections was transferred to IPK by 2004.
d) Excluding accessions held in field genebanks, but including special seed collections and genetic stocks. Additional data from country report Sweden,1995.
e) NPGS includes the following repository centres: C.M. Rick Tomato Genetic Resources Center (GSLY), Davis, California; Clover Collection, Department of Agronomy, University of Kentucky (CLO), Lexington, Kentucky; Crop Germplasm Research Unit (COT), College Station, Texas; Dale Bumpers National Rice Research Center (DB NRRC), Stuttgart, Arkansas; Desert Legume Program (DLEG), Tucson, Arizona; Fruit Laboratory, ARS Plant Germplasm Quarantine Office (PGQO), Beltsville, Maryland; G.A. Marx Pea Genetic Stock Center, Western Regional Plant Introduction Station (GSPI), Pullman, Washington; Maize Genetics Cooperation - Stock Center (MGCSC; GSZE), Urbana, Illinois; National Arctic Plant Genetic Resources Unit, Alaska Plant Materials Center (PALM), Palmer, Alaska; National Arid Land Plant Genetic Resources Unit (PARL), Parlier, California; National Center for Genetic Resources Preservation (NCGRP), Fort Collins, Colorado; National Clonal Germplasm Repository (COR), Corvallis, Oregon; National Clonal Germplasm Repository for Citrus & Dates (NCGRCD), Riverside, California; National Germplasm Repository (DAV), Davis, California; National Germplasm Repository (HILO), Hilo, Hawaii; National Germplasm Resources Laboratory (NGRL), Beltsville, Maryland; National Small Grains Germplasm Research Facility (NSGC), Aberdeen, Idaho; National Tree Seed Laboratory, Dry Branch, Georgia; North Central Regional Plant Introduction Station (NC7), Ames, Indiana; Northeast Regional Plant Introduction Station, Plant Genetic Resources Unit (NE9), Geneva, New York; Ornamental Plant Germplasm Center (OPGC), Columbus, Ohio; Oxford Tobacco Research Station (TOB), Oxford, North Carolina; Pecan Breeding & Genetics, National Germplasm Repository (BRW), Somerville, Texas; Plant Genetic Resources Conservation Unit, Southern Regional Plant Introduction Station (S9), Griffin, Georgia; Plant Genetic Resources Unit, New York State Agricultural Experiment Station (GEN), Geneva, New York; Potato Germplasm Introduction Station (NR6), Sturgeon Bay, Wisconsin.

While it appears that substantially more diversity is now conserved *ex situ* than a decade ago, a word of caution is warranted, as suggested above. Some and perhaps most of the increases, result from exchange of existing accessions among collections, leading to an overall increase in the amount of duplication.[11] In addition, at least part of the change might reflect better management of the collections. Furthermore, numbers are not necessarily synonymous with diversity. Sometimes a smaller collection can be more diverse than a larger one.

Efforts to rationalize collections have been reported by several genebanks and networks. One example is an initiative of the European Collaborative Programme for Plant Genetic Resources (ECPGR) to rationalize European plant genetic resources collections that are dispersed over approximately 500 holders and 45 countries. The identification of undesirable duplicates is an important component of the initiative. The so-called 'most appropriate accessions' are being identified among duplicate accessions, based on criteria such as genetic uniqueness, economic importance, ease of access, conservation status and information status. The adoption of common data standards can greatly facilitate the comparison of data and hence the identification of duplicates and unique accessions.[12]

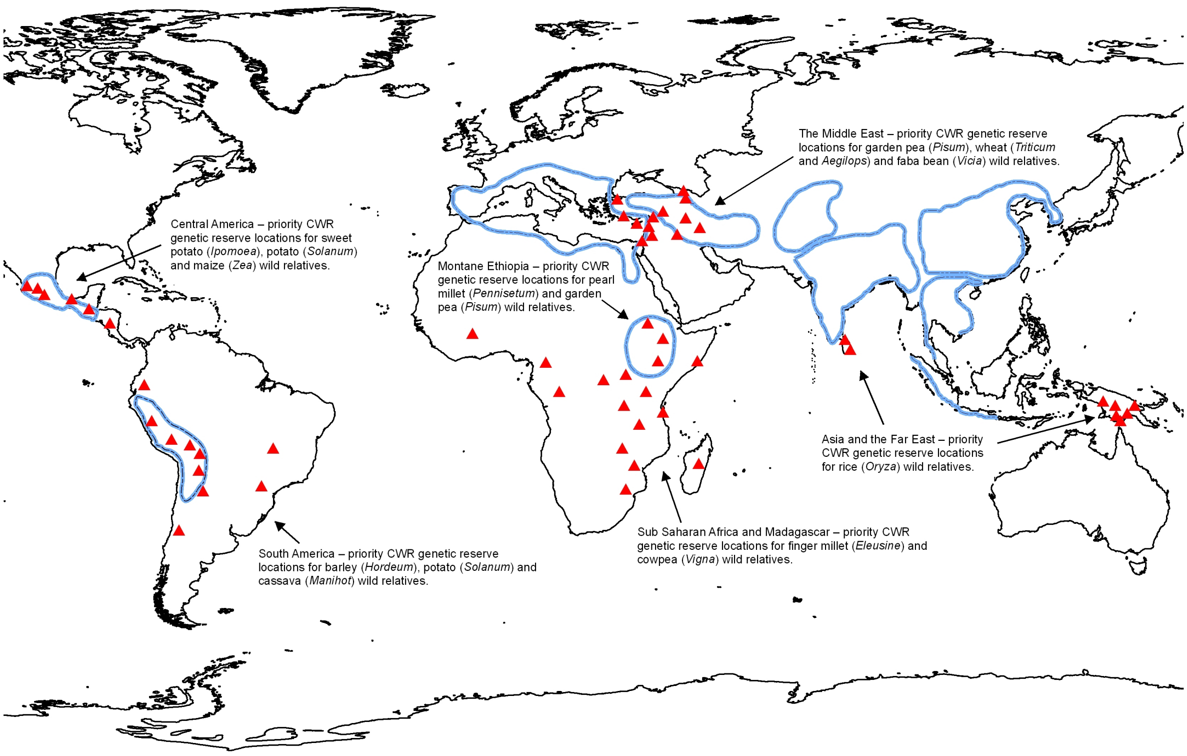
1.2.3 The status of crop wild relatives

More information on the *in situ* management of CWR is given in Chapter 2, and figures on *ex situ* conservation are provided in Chapter 3. While *ex situ* conservation and on farm management methods are most appropriate for conserving domesticated crop germplasm, for CWR and species harvested from the wild, *in situ* conservation, backed up by *ex situ* methods, is generally the strategy of choice. In spite of a growing appreciation of the importance of CWR, as evidenced by many country reports, the diversity within many species and in some cases even their continued existence remains under threat as a result of changes in land use practices, climate change and the loss or degradation of natural habitats.

Many new sites for conserving CWR *in situ* have been identified around the world over the last decade, generally following some form of eco-geographic survey.[13] In some cases, new protected areas have been proposed for conserving a single genus or even species. The diversity of CWR in some protected areas has decreased over this period while others still harbour significant diversity.

The distribution across regions of reserves that include populations of CWR within their boundaries remains uneven, and several major regions, such as Sub-Saharan Africa, are still under-represented. However, the *in situ* conservation of CWR has gained increasing attention in many countries, for example those that participate in a project managed by Bioversity International entitled '*In situ* conservation of crop wild relatives through enhanced information management and field application' (see Box 1.1). Preparatory activities, such as research and site selection, have been mentioned in several country reports, although the need often remains for formal recognition and/or the adoption of appropriate management regimes. The Commission on Genetic Resources for Food and Agriculture (CGRFA) has recently commissioned a report on the "Establishment of a global network for the *in situ* conservation of CWR: status and needs".[14] This report identifies global conservation priorities and suggests locations for reserves for CWR of 12 selected crops (see Figure 1.1). These, together with additional priority locations to be indentified in the future when further crop gene pools are studied, will form a global CWR *in situ* conservation network.

Figure 1.1 Global priority genetic reserve locations for wild relatives of 12 food crops

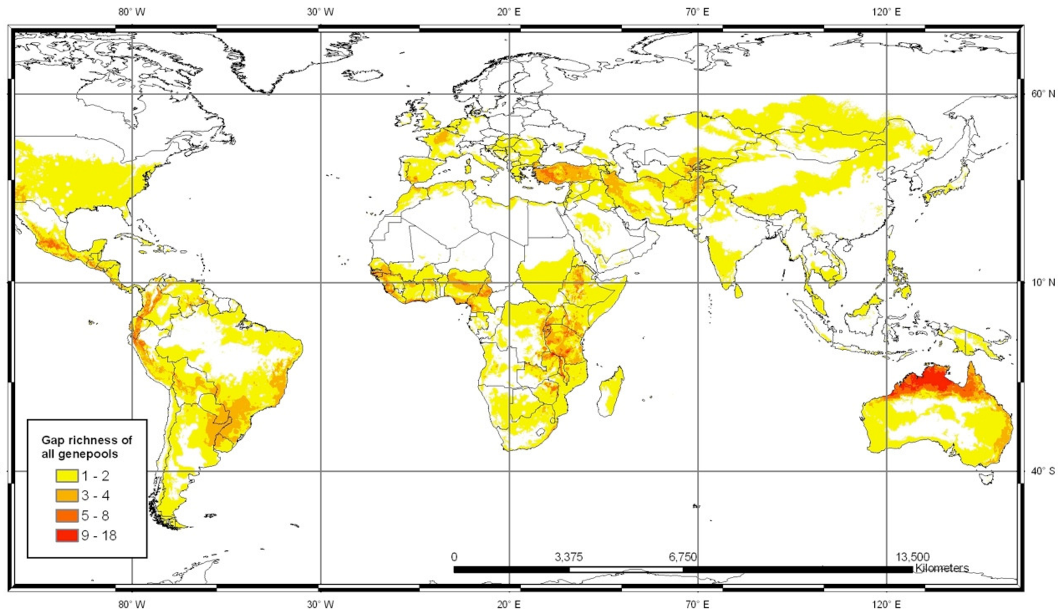


The eight Vavilov centres of origin/diversity of cultivated plants (indicated by the enclosed lines) are likely to contain further priority sites for other crop gene pools

The threat of climate change to CWR has been highlighted by a recent study[15] that focused on three important crop genera: *Arachis*, *Solanum* and *Vigna.* The study predicts that 16–22% of species in these genera will become extinct before 2055 and calls for immediate action to preserve CWR *ex situ* as well as *in situ.* Back-up samples conserved *ex situ* will become increasingly important, especially when environmental change is too rapid for evolutionary change and adaptation, or migration (even assisted migration), to be effective. Samples stored *ex situ* also have the advantage of being more readily accessible, and as they do not evolve over time, data and information on them remain relevant and they can be studied more intensively. Significant gaps exist in the taxonomic and geographic coverage of CWR in *ex situ* collections. A recent study by the International Center for Tropical Agriculture

(CIAT) and Bioversity International has highlighted these gaps for a number of genepools. Figure1.2 summarizes the findings for the 12 crops in question.[16] It highlights areas of the world where, for these 12 crops, CWR species are expected to exist, based on herbarium specimens, but are, however, missing from *ex situ* collections.

Figure 1.2 Gaps in *ex situ* collections of selected crop genepools



1.2.4 The impact of technological developments in managing diversity

Advances in research techniques and their greater availability during the past decade have resulted in some significant new insights into the extent and distribution of genetic diversity, both in space and time.

1.2.4.1 Molecular technologies

Since the first SoW report was published, there has been a proliferation of new molecular techniques, many of which are simpler to use and less expensive than earlier techniques. This has led to the generation of a vast and rapidly increasing amount of data on genetic diversity, much of which is publicly available. The huge increase in DNA sequence capacity has, for example, enabled the rice genome to be sequenced, as well as comparisons to be made between the japonica and indica rice genomes and between rice and wheat genomes.[17] The application of molecular techniques is increasing rapidly both in crop improvement (see Chapter 4.4) and in the conservation of plant genetic resources. However, this has generally been slower than was foreseen a decade ago and few country reports, especially from the less developed countries, mention these techniques[18] (Box 1.1 gives some examples).

While many molecular techniques, from allele identification and marker-assisted selection to gene transformation, have been developed specifically to enhance crop improvement, many are also proving invaluable in conservation. This includes, for example: techniques for estimating the spatial and temporal distribution of genetic diversity and relationships between and within populations;[19] gaining insights into crop domestication and evolution;[20], [21] monitoring gene flows between domesticated and wild populations;[22] and increasing the efficiency and effectiveness of genebank operations[23] (e.g. deciding what material to include within a collection;[24] identifying duplicates;[11] increasing the efficiency of regeneration,[25] and establishing core collections). As a result, much more is known about the history and structure of genetic diversity in key crop genepools than was the case a decade ago.

1.2.4.2 Geographic Information Systems

New geographic methods are also proving to be of significant value in the management of plant genetic resources. Global Positioning Systems (GPS) are highly effective at pinpointing the exact location where a plant was collected in the field. Such data can be invaluable, especially when combined with other geo-referenced data, e.g. on topography, climate or soils, and analyzed using geographic information systems (GIS) software. Such information can greatly facilitate decisions on what to collect and where, and help elucidate relationships between crop production, genetic diversity and various agro-ecological parameters. Such techniques can also be used to draw up agro-ecological models that can predict, for example, the impact of climate change on different crops and in different locations. These methods have been demonstrated by the Focused Identification of Germplasm Strategy (FIGS) to also have a significant impact on the effectiveness and efficiency in 'mining' germplasm for specific adaptive traits for plant improvement.[26]

No country report indicates the extent to which geographic information tools are available and used within the country concerned, and most of the reports that do mention studies involving GIS do not describe outcomes of the work. Rather, such studies appear to have been largely subsumed within crop distribution, eco-geographic and similar studies. Their relevance to PGRFA management is not generally as well recognized as it perhaps should be.

1.2.4.3 Information and Communications Technologies

The ability to measure and monitor the state of diversity has benefited from huge advances in information and communications technologies during the past decade, in the form of faster and cheaper computer processors with larger memory and storage capacities, incorporated into a wide range of instruments and devices, with more advanced software and better user interfaces. The speed and effectiveness of communication and of gathering, managing and sharing data have improved dramatically since 1996 as a result of the incorporation of computers into data capture devices, improvements in data and database management software, and the expansion of local computer networks and the Internet. These improvements have also resulted in rapid advances in the ability to undertake sophisticated processing and analysis of large complex datasets as, for example, in the emergence and application of the science of bioinformatics for molecular data.

1.3 Genetic vulnerability and erosion

Genetic vulnerability is the condition that results when a widely planted crop is uniformly genetically susceptible to a pest, pathogen or environmental hazard, thereby creating a potential for widespread crop losses.[27] Vulnerability may occur at the level of a genepool, or in a specific geographical area.[28]

Genetic erosion has been defined as 'the permanent reduction in richness (or evenness) of common local alleles, or the loss of combinations of alleles over time in a defined area'.[29] Thus while genetic erosion does not necessarily entail the extinction of a species or sub-population, it does signify a loss of variability and thus a loss of flexibility and robustness, affecting a crop's performance.[30]
The definitions above refer to both richness and evenness of allelic diversity, the first relating to the total diversity present and the second to the balance between specific alleles in a

given genepool. While there has been much discussion of these concepts since the first SoW report, these definitions have not changed.

1.3.1 Trends in genetic vulnerability and erosion

While few country reports give concrete examples, about 50 report that genetic vulnerability is important and many mention the need for a greater deployment of genetic diversity in order to counter the potential threat to agricultural production. In Benin, for example, there is concern that the current agricultural system is dominated by monocultures of basic food crops, in particular yam and commercial crops. China reports cases in which rice and maize varieties have become more uniform and genetically vulnerable. Nepal reports that the emergence of brown plant hopper in the Terai region in 1998 and 1999 was attributed to declining rice diversity, and in Lebanon the decrease in the national production of almonds has been attributed to the genetic vulnerability of the few varieties grown. On the other hand, some countries report on successful measures to counter genetic vulnerability. Cuba, for example, reports that the introduction of a wide range of varieties and the increasing use of diversified production systems has reduced genetic vulnerability. Thailand promotes the use of greater diversity in breeding programmes and released varieties. The largest global example of genetic vulnerability that has occurred since the first SoW report was published is the outbreak and continued spread of stem rust race Ug99 of wheat, to which the large majority of existing wheat varieties are susceptible.

In the case of genetic erosion, while the country reports mentioned a substantial number of causes, in general these were the same as those identified in 1996. Major causes included: replacement of local varieties, land clearing, over-exploitation, population pressures, environmental degradation, changing agricultural systems, over-grazing, legislation and policy, and pests, diseases and weeds. From an analysis of the country reports it also appears that that genetic erosion may be greatest in cereals, followed by fruit and nuts, food legumes and vegetables (see Table 1.3). This may however be an artifact of the greater attention generally paid to field crops.

Table 1.3 Crop groups and number of countries that provide examples of genetic erosion in a crop group

Crop group	Number of countries
Cereals and grasses	27
Crop wild relatives	3
Forestry species	7
Fruit and nut crops	17
Industrial crops	2
Legumes	16
Medicinal and aromatic plants	7
Oil crops	2
Roots and tuber crops	11
Stimulants and spices	5
Vegetables	16

The following examples of genetic erosion cited in country reports give a flavour of the diversity of situations. However, in order for such information to be useful as a baseline, there is a need to standardize the definition of genetic erosion so that the information is comparable across countries. Madagascar reported that the rice variety Rojomena, appreciated for its taste, is now rare whereas the Botojingo and Java varieties of the north-eastern coastal area have disappeared. The cassava variety Pelamainty de Taolagnaro and certain varieties of bean have disappeared from most producing areas and in coffee, 100 clones out of 256 as well as five species (*C. campaniensis*, *C. arnoldiana, C. rostandii, C. tricalysioides* and *C. humbertii*) have disappeared from collections in the last 20 years. Wild yam species are also considered likely to disappear soon. Costa Rica reports that *Phaseolus* spp., including P*. vulgaris*, are threatened by serious genetic erosion as is the indigenous crop *Sechium tacaco* and four related species: *S. pittieri*, *S. talamancense, S. venosum* and *S. vellosum*. In India, a large number of rice varieties in Orissa, rice varieties with medicinal properties in Kerala, and a range of millet species in Tamil Nadu, are no longer cultivated in their native habitats.[31] In Albania, all primitive wheat cultivars and many maize cultivars have reportedly been lost.

Notwithstanding reports of the loss of local varieties, landraces and CWR such as these, the situation regarding the true extent of genetic erosion is clearly very complex. While many recent studies have confirmed that diversity in farmers' fields and in protected areas have indeed eroded, it is not possible to generalize and under certain conditions there is a lack of evidence that it has occurred at all. For example, a large on farm conservation project that studied genetic diversity in farmers' fields in nine countries found that, overall, crop genetic diversity continued to be maintained.[32] Other studies, however, have reported genetic shifts in farmers' varieties, for example in pearl millet in Niger[33] and sorghum in Cameroon,[34] and in studies on the adoption by farmers of improved varieties of rice in India[35] and Nepal,[36] it was found that adoption can result in substantial disappearance of farmers' varieties. On the other hand, it has also been noted that many farmers who plant modern varieties (especially large and medium land holders) also tend to maintain their landraces and that in such circumstances adoption of modern varieties might increase on farm diversity rather than reduce it.[37] In summary, it seems that statements quantifying the overall amount of genetic erosion that has occurred over the past decade and more should be treated with caution.

As with the situation of traditional farmer varieties and CWR, studies on diversity trends in released varieties over time also give no consistent picture. Some report no reduction or even an increase in genetic diversity and allelic richness in released varieties, for example in the International Maize and Wheat Improvement Center (CIMMYT) related spring bread wheat varieties,[38] maize and pea varieties in France[39] and barley in Austria and India.[28] In cases such as these, the new varieties may be less vulnerable than was originally thought. Other studies report either an initial decrease followed by an increase of genetic diversity, e.g. in indica and japonica rice varieties in China,[40] or a continuous decline such as for wheat in China,[41] oats in Canada,[42] and maize in Central Europe.[43] A meta analysis based on these and other published reports on diversity trends has shown that, overall, there appears to have been no substantial reduction in genetic diversity as a result of crop breeding in the 20th century and no overall gradual narrowing of the genetic base of the varieties released.[44] However, the context of the meta analysis needs to be carefully analyzed to understand how widely applicable the results might be, in particular to developing country conditions.

1.3.2 Indicators of genetic erosion and vulnerability

Over the last decade, interest in direct or indirect indicators of genetic vulnerability and erosion has increased, at least in part due to the paucity of direct evidence for either event. The CGRFA called for the development of 'higher level indicators' for genetic erosion and genetic vulnerability in relation to monitoring the implementation of the Global Plan of Action for the Conservation and Utilization of PGRFA (GPA).

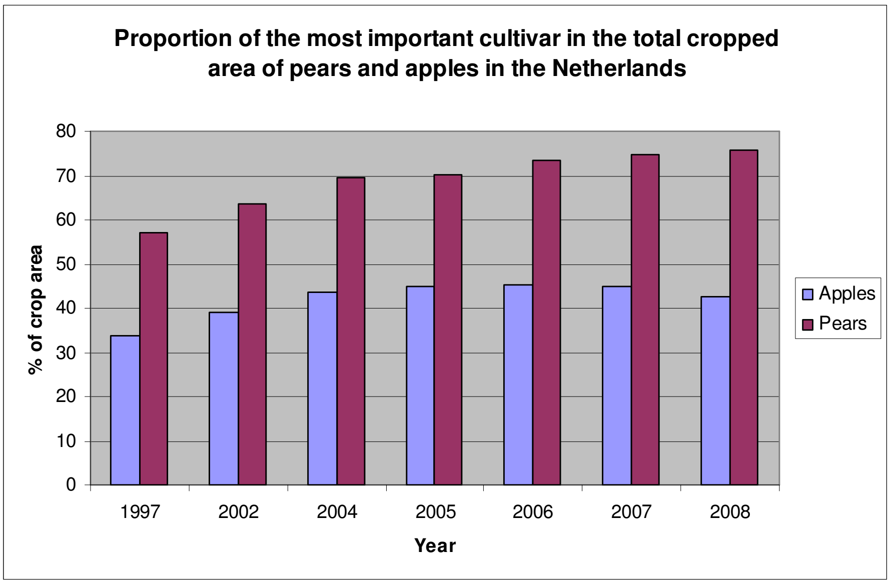
The 2010 Biodiversity Indicators Programme under the auspices of the Convention on Biological Diversity (CBD) brings together a large number of international organisations to develop indicators relevant to the CBD, including ones for monitoring trends in genetic diversity. However, to date no really practical, informative and generally accepted indicators of genetic erosion are available and their development should be a priority. Several qualities are important for such indicators to be effective:

- They should be sensitive to changes in the frequency of important alleles: the loss of an allele at a highly polymorphic microsatellite locus, for example, is likely to be of only minor importance compared to the loss of a disease resistance allele;
- They should provide a measure of the significance of the potential loss, e.g. by estimating the fraction of genetic information at risk compared with the total diversity;
- They should enable an assessment to be made of the likelihood of loss over a specific time period, in the absence of human intervention.

Indicators for estimating genetic vulnerability should consider not only the extent of genetic uniformity *per se,* but also take into consideration possible genotype x environment interactions. A given genotype (population or variety) might succumb to a particular biotic or abiotic stress differently in different environments. Useful indicators of genetic vulnerability might include:

- The extent of genetic diversity of genes conferring resistance to, or tolerance of, actual and potential major pests and diseases or abiotic stresses;
- The extent of diversity in host-pathogen interactions and the occurrence of differential responses to different biotypes of pests and diseases. This indicator would provide information on the variety of coping mechanisms available and hence the likelihood of a shift in pathogen population resulting in widespread virulence;
- The occurrence of severe bottlenecks during domestication, migration or breeding: indicators of a genetic bottleneck could be derived from molecular data, historic information or pedigree analyses;
- The extent to which single varieties dominate over large areas could be a useful first indicator for estimating genetic vulnerability, based on the assumption that genetic vulnerability is higher when large areas are cropped with one variety. Figure 1.3 gives an example of this for pears and apples in the Netherlands);
- The genetic distances between the parental lines of a variety could be a proxy indicator, in certain circumstances, for the degree of heterogeneity, and hence genetic vulnerability of the variety.

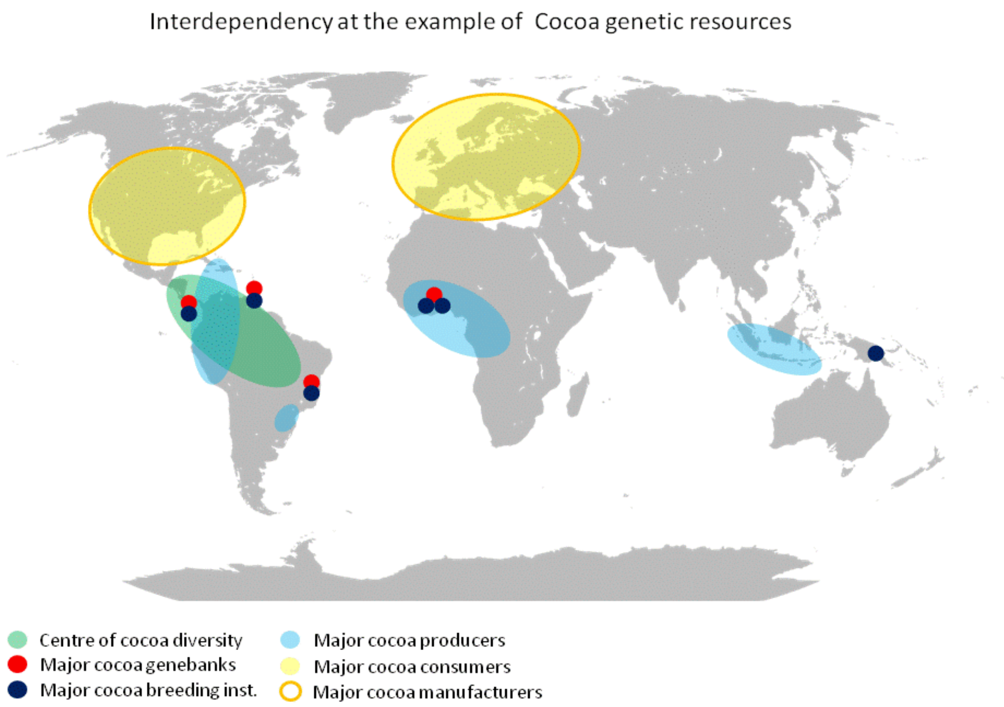
Figure 1.3 Possible indicator to assess the potential genetic vulnerability of a crop



1.4. Interdependence

Interdependence regarding PGRFA can take many forms and may involve a wide range of stakeholders over space and/or time. Most crops, CWR and other useful wild plant species, are not confined within national boundaries. Their distribution reflects the distribution of ecosystems and global dispersal by humans or nature. As a result, people interested in using PGRFA often have to access material, and the knowledge that goes with it, from beyond their own national borders. Whereas all countries are both providers and recipients of PGRFA, not all countries have been equally endowed with them, or with the capacity to use them. This has led to a mutual but unequal interdependence, which can be seen as either a potential threat to national sovereignty or as an opportunity for constructive collaboration[45] (see Figure 1.4 and Table 1.4).

Figure 1.4 Global interdependence illustrated by the example of cocoa



The concept of interdependence applies not only at the international level, but also in the roles of farmers, breeders and genetic resource managers. Farmers are the managers of genetic resources they grow, genebank managers have been entrusted with safeguarding collections of this diversity, and breeders, to a large extent, depend on both for the genetic diversity they need.

Considerable interdependence also occurs at the local level between farmers who frequently trade or barter seed and other planting materials with each other. Local systems of germplasm exchange are often deeply ingrained in rural societies and may be an important element in relationships among families and local communities. Such systems are generally ‘robust’ and able to cope well under stress[46] when their high level of interdependence contributes to their resilience.

A major consequence of interdependence among nations is the need for international exchange of germplasm. Studies have suggested that in many cases such exchange has become more complex and difficult over recent years. There is a danger that reduced international flows of PGRFA may pose a threat not only to its use, but also to its conservation and ultimately to food security.

With the growing impact of climate change, there will undoubtedly be an increase in demand for varieties that are adapted to the new environmental conditions and pest and disease spectra. The ability to access a wide range of genetic diversity is central to meeting this demand, implying that in future there will be even greater interdependence between countries and regions than is the case today.

Uncertainty about legal issues is widely considered to be a significant factor hindering international, and even national, germplasm exchange. While CBD has been in force for many years, a lack of clear and efficient procedures for accessing PGRFA still hampers the collection and/or cross-boundary movement of genetic resources in many countries (see Chapter 7). Likewise, a number of national governments have yet to ratify the ITPGRFA or put in place the necessary procedures to ensure its effective implementation.

Table 1.4 Indicators of global interdependency of selected crop

	Region(s) of significant genetic diversity[1]	Major *ex situ* collections[2]	Major producing countries[3]	Major breeding and research activities	Countries for which major consumption has been recorded[4]		Major importing countries[5]
Cacao (*Theobroma cacao*)	Amazon Basin and Central America	Brazil, Trinidad and Tobago, Venezuela, Costa Rica	Côte d'Ivoire, Ghana, Indonesia, Nigeria, Brazil	Trinidad and Tobago, Brazil, Costa Rica, Ghana, Côte d'Ivoire, Papua New Guinea	USA, France, Germany, Russian Federation, Japan		Cocoa, beans Netherlands, USA, Malaysia, Germany, Belgium
Quinoa (*Chenopodium quinoa*)	Andean Cordillera	USA, CGIAR	Peru, Bolivia, Ecuador	Peru, Bolivia,	Bolivia, Peru, USA, Europe, Canada		N/A
Soybean (*Glycine max*)	East Asia	China, AVRDC (Regional), USA, Ukraine, Russia	USA, Brazil, Argentina, China, India		Seed China, Indonesia, Japan, Brazil, Rep. of Korea	Oil China, USA, Brazil, India, Japan	Soybeans China, Netherlands, Japan, Mexico, Germany
Safflower (*Carthamus tinctorius*)	Far East, India-Pakistan, the Middle East, Egypt, Sudan, Ethiopia, Southern Europe	Mexico, India, China, Ethiopia, USA	India, USA, Kazakhstan, Australia, China	Australia, Canada, China, India, Mexico, Spain, USA,	Seed Belgium, Nether-lands, China, UK, Philippines	Oil USA, Nether-lands, Japan, Germany, Yemen	Safflower, seed Belgium, Netherlands, China, UK, Philippines
Noug (*Guizotia abyssinica*)	Horn of Africa	Ethiopia, India	Ethiopia, India, Nepal	Ethiopia, India	Ethiopia, India, USA, United Kingdom, Nepal		USA, United Kingdom
Sesame (*Sesamum indicum*)	Horn of Africa, India, China, Central Asia, and the Near East	Israel, China, India, Mexico, Venezuela	India, Myanmar, China, Sudan, Uganda	India, Turkey, USA,	Seed India, China, Uganda, Egypt, Japan	Oil China, India, Myanmar, Sudan, Rep. of Korea	Sesame, seed China, Japan, Republic of Korea, Turkey, Syrian Arab Republic
Eggplant (*Solanum melongena*)	Indo-Myanmar region	AVRDC, India,	China, India, Egypt, Turkey, Indonesia	AVRDC, India,	India, China, Nepal, Pakistan, Sri Lanka, Nepal, Malaysia, Indonesia, African countries		Eggplant Iraq, USA, France, Germany, United Kingdom
Sunflower (*Helianthus annuus*)	North America	Romania, Serbia, USA, Russia, France	Russia, Ukraine, Argentina, China, India, France, USA, Hungary, Turkey	USA, Russia	Seed USA, Spain, Myanmar, Bulgaria, Brazil	Oil Russia, China, Ukraine, India, Spain	Sunflower, seed Spain, Netherlands, Turkey, Italy, France
Groundnut (*Arachis hyogea*)	South America	ICRISAT, USDA, India, China, Senegal	China, India, Nigeria, USA, Indonesia	India, China, USA, Australia,	Confectionary China, USA, Indonesia, India, Nigeria	Oil China, India, Nigeria, Sudan, Myanmar	Groundnut, shelled Netherlands, Russian Federation, Mexico, Canada, United Kingdom
Rice (*Oryza* spp.)	South, East, and South-East Asia, Africa	Philippines (CGIAR), China, India, USA, Benin (CGIAR), Thailand	China, India, Indonesia, Bangladesh, Vietnam	Philippines (CGIAR), USA, China, India,	China, India, Indonesia, Bangladesh, Vietnam		Rice, milled Philippines, Iraq, Islamic Republic of Iran, Nigeria, Saudi Arabia
Oil Palm (*Elais* spp)	West Africa, Amazon Basin	Malaysia, Brazil, Ghana	Indonesia, Malaysia, Nigeria, Thailand, Colombia	MPOB, Malaysia	India, China, Indonesia, Pakistan, Nigeria		Palm oil China, India, Netherlands, Pakistan, Germany

[1] Source: first SoW report
[2] Source: first SoW report and country report of the second SoW report
[3] Souce: FAOSTAT 2007
[4] Source: FAOSTAT 2003; for safflower import data for 2006; for quinoa and eggplant anecdotal evidence
[5] Source; FAOSTAT 2006

Just as the world's plant genetic resources are unevenly distributed, so is the capacity to use them. Many countries lack adequate institutions, facilities or breeders to effectively undertake modern – or even conventional - crop improvement work, especially on minor crops. Thus there is still a heavy reliance by many countries on outside support for plant breeding, whether directly for improved varieties or indirectly through training and research collaboration. There have been a number of positive developments in this regard recently, including the Global Partnership Initiative for Plant Breeding Capacity Building (GIPB)[47] and the development of regional centres of excellence for biotechnology, such as Biosciences Eastern and Central Africa (BECA).[48] Such centres enable scientists from developing countries to apply their knowledge and skills to specific national crop improvement challenges. These and other, similar initiatives are an important aspect of interdependence and are an integral part of systems for benefit sharing. More detail on the status of crop improvement and other uses of PGRFA is provided in Chapter 4.

1.5 Changes since the first SoW report was published

Key changes that have occurred in relation to the state of diversity since the publication of the first SoW report include:

- *Ex situ* collections have grown substantially, both through new collecting and through exchange among genebanks. The latter has contributed to the continuing problem of excessive duplication;
- Scientific understanding of the on farm management of genetic diversity has increased, and this approach to the conservation and use of PGRFA has become increasingly mainstreamed within national programmes;
- Interest in and awareness of the importance of conserving CWR, both *ex situ* and *in situ,* and its use in crop improvement have increased substantially;
- There is growing interest in hitherto ‘neglected’ and under-utilized species categories such as traditional vegetables and fruits;
- With modern molecular genetic techniques, it has been possible to generate a large amount of data on the extent and nature of genetic erosion and vulnerability in particular crops in particular areas. However, the picture that is emerging is complex and it is not possible to generalize about the magnitude and extent of these effects;
- The extent of interdependence among countries with respect to their need to have access to materials held by others is arguably more important than ever. This is especially true in the face of the need to develop varieties that are adapted to the new environmental conditions and pest and disease spectra that will result from climate change. The ITPGRFA has provided a sound basis for improving and facilitating such assess.

1.6 Gaps and needs

Based on the information provided in this chapter, the following lists some of the major gaps and needs with respect to genetic diversity:

- There is still an ongoing need to improve the coverage of diversity in *ex situ* collections, including CWR and farmers’ varieties, coupled with adequate characterization, evaluation and documentation of the collections;
- A better understanding of, and support for, farmers’ management of PGRFA is still needed, in spite of significant advances in this area. Opportunities exist for improving the livelihoods of rural communities in the process;

- There is still a need for greater rationalization of the global system of *ex situ* collections, as called for in the Global Plan of Action (GPA) and the ITPGRFA, and as reflected in initiatives such as those of the Global Crop Diversity Trust (GCDT) and AEGIS;
- Greater attention is needed regarding the conservation and use of PGRFA of neglected and under-utilized crops and non-food crops. Many such species can make a valuable contribution to improving diets and incomes;
- There is a need to reach agreement on standard definitions of genetic vulnerability and genetic erosion, as well as for more, and more useful, indicators in order to be able to better establish national, regional and global baselines for monitoring diversity and changes in it, and for establishing effective early warning systems;
- Many countries still lack national strategies and/or action plans - or if they have them, they do not fully implement them. Areas that require particular attention include setting priorities, enhancing national and international cooperation and identifying gaps in the conservation of PGRFA, including CWR;
- In spite of the growing awareness of the importance of CWR, there is still a need in many countries for appropriate policies, legislation and procedures for collecting CWR, for establishing protected areas for CWR, and for better national coordination of these efforts.

Box 1.1 Some selected examples of the use of molecular and GIS tools in the conservation and characterization, as reported by countries

Africa

- *Benin:* Molecular characterization of yam germplasm has been initiated.
- *Egypt:* Molecular genetic data employed in PGR evaluation of accessions in national genebank.
- *Ethiopia:* Molecular techniques used in characterization and genetic diversity studies for several field crop species.
- *Kenya*: Application of RFLPs, DNA finger printing, and PCR techniques.
- *Malawi*: Molecular characterization of sorghum accessions has been initiated.
- *Morocco*: Molecular markers and GIS have been used in evaluation of germplasm of cereals to target regions for collection.
- *Namibia*: Genetic diversity studies in sorghum and *Citrullus*.

Americas

- *Argentina*: Approximately half of the *ex situ* collections have been characterized using molecular markers (mainly horticultural species).
- *Bolivia*: Molecular characterization has been applied to a limited number of collections, primarily Andean root and tuber crops.
- *Costa Rica*: Molecular characterization has been carried out for clones of chayote, banana germplasm, cocoa, and in the establishment of the world's first cryo-seed bank for coffee. In general, molecular characterization has proved very useful for verifying genetic identity of accessions.
- *Jamaica*: Molecular marker-assisted breeding was adopted in the improvement of scotch bonnet peppers and a state-of-the-art molecular biology laboratory is in use for coconut variety improvement.
- *Mexico*: Sequencing and transcript analysis has been carried out with accessions of *Agave tequilana* at the Campeche Campus of the Colegio de Postgraduados.
- *Peru*: Molecular characterization has been carried out with accessions of yuca, yacon, mani, aji (chile), and 75 varieties of native potato.
- *Venezuela*: Marker-assisted selection has been used in the development of maize lines with high protein quality. Molecular characterization of sugar cane, cacao, potato, and cotton genebank accessions, among other taxa, has been carried out.

Asia and the Pacific

- *China:* On the basis of modern molecular marker technology, core collections and mini-core collections have been assembled for many crops and used to associate molecular markers with targeted genes. In addition, training programs have extended these techniques to scientists from developing countries.
- *Fiji:* With collaboration from regional and international institutions, molecular approaches have been used in germplasm characterization.
- *India:* Molecular markers for disease and insect-pest resistance have been deployed for wheat and triticale improvement.
- *Indonesia:* Analysis of molecular genetic diversity was used to confirm Papua as a secondary center of diversity for sweet potato. Molecular markers have been in use for several years for characterization of accessions of several food crops (rice, soybean, and sweet potato) and for crop improvement programs.
- *Japan:* Molecular markers have been integrated into the characterization activity of the national genebank and marker-assisted selection is routine for improvement of crops such as rice, wheat, and soybeans.
- *Lao PDR:* Molecular markers for QTL traits have been incorporated into rice breeding programs.
- *Thailand*: Genetic diversity of *Curcuma*, mangrove tree species (*Rhizophora mucronata*), and *Tectona grandis. Thailand* has also used agro-climatic data together with molecular marker data in GIS studies to predict the location of diverse populations in order to identify areas for *in situ* conservation and for future collecting missions.

Europe

- *Belgium:* The majority of the 1600 apple accessions in the Center for Fruit Culture have been described by use of molecular markers.
- *Cyprus*: Assessment of molecular diversity in tomato, grape, and pomegranate.
- *Finland*: Molecular marker analysis has been used in estimations of genetic diversity in crop wild relatives.
- *Greece*: Molecular characterization and evaluation of cereal and vegetable crops has been initiated.
- *Ireland*: Analysis of the diversity of collected samples of wild oats (*Avena fatua*); wild rape (*Brassica rapa* subsp. *campestris*), and Irish populations of wild asparagus (*Asparagus officinalis* ssp. *prostratus*).
- *Italy*: Molecular analysis has played a key role in evaluating the genetic variation expressed in clones of the same variety for some fruit species.
- *Portugal*: Molecular characterization of plum, apricot, cherry, and almond accessions in national collections have been partially carried out.

Near East

- *Jordan:* Molecular biology laboratories are in place at the national research center as well as at several universities, and GIS and remote sensing are being used in three institutions.
- *Lebanon:* Molecular genetic characterization has been conducted for olive and almond varieties.
- *Oman:* Molecular markers used for characterizing alfalfa accessions (RAPDs) and evaluating progeny in date palm breeding populations (AFLPs).
- *Yemen*: The national genetic resources center has the capacity for undertaking molecular characterization of germplasm.

[1] Reilly J and Schimmelpfennig D (1999) Agricultural impact assessment, vulnerability, and the scope for adaptation. Climatic change, 43:745-788

[2] Lobell DL, Burke MB, Tebaldi C, Mastrandea MD, Falcon WP and Naylor RL (2008) Prioritizing Climate Change Adaptation Needs for Food Security in 2030. Science 319: 607-610

[3] Jarvis DI et al (2007) A global perspective of the richness and evenness of traditional crop-variety diversity maintained by farming communities. Proc Natl Acad Sci USA 105: 5326-5331

[4] Rosegrant MW and Cline SA (2003) Global food security: challenges and policies. *Science*, 302:1917-1919

[5] The world's top 10 food manufacturers rank amongst the 400 largest companies in terms of market value, with a joint turnover of more than US$ 200,000 million. The market share of the top 20 largest food manufacturers in the USA has doubled since 1967and the share held by the top three grocery retailers in EU countries varies from 40% (Germany, UK) to over 80% (Finland, Ireland). Lang T (2003) Food industrialisation and food power: Implications for food governance. Development Policy Rev 21: 555 – 568.

[6] By 2002, the share of supermarkets in processed/packaged food retail market was 33% in Southeast Asia, and 63% in East Asia. The share of supermarkets in fresh foods was roughly 15–20% in Southeast Asia and 30% in East Asia outside China. The 2001 supermarket share of Chinese urban food markets was 48%, up from 30% in 1999. Pingali P. (2006) Food policy 32: 281 – 298.

[7] In the context of this chapter staple crops include the large cereals (wheat, maize, rice, sorghum and barley), beans, cowpea, groundnut, potato, banana and cassava.

[8] Chapter 3.3.4 in SoW 1, Coverage of collections and reaming gaps.

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Chapter 2

The state of *in situ* management

2.1 Introduction

The CBD defines *in situ* conservation as 'the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings, and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties.' While the concept has evolved since the CBD was adopted, this definition is used in several major international treaties and initiatives including the ITPGRFA and the Global Strategy on Plant Conservation. *In situ* conservation is often envisaged as the creation of protected areas or habitats (as opposed to *ex situ* conservation) and depending on the interest group it can either be targeted at species or the ecosystem in which they occur. It is a particularly important method of conservation for species that are difficult to conserve *ex situ,* such as many wild crop relatives.

The on farm conservation and management of PGRFA is often regarded as a form of *in situ* conservation. However, in many cases the reasons why farmers continue to grow traditional varieties may have little to do with the desire to conserve and much more to do with reasons of tradition and preferences, risk avoidance, local adaptation, niche market opportunities or simply the lack of a better alternative. Nevertheless, much important diversity continues to be maintained on farm and efforts to better manage and use it have gained much ground during the past decade. There is now a clearer understanding of the factors involved.[1]

This chapter describes progress that has been made since the first SoW report in the management of PGRFA in wild ecosystems, agricultural production systems and the interface between these two. It reviews (i) new knowledge regarding the amount and distribution of *in situ* diversity and new tools available for such research; (ii) progress in understanding the processes that shape the evolution of diversity *in situ*; and (iii) current capacity for conserving and using diversity *in situ*. The chapter concludes with a summary of the main changes that have occurred since the first SoW report was published and identifies further gaps and needs.

2.2 Conservation and management of PGRFA in wild ecosystems

Many plant species growing in wild ecosystems are valuable for food and agriculture and often play an important cultural role in local societies. They can provide a safety net when food is scarce and are increasingly marketed locally and internationally, providing an important contribution to household incomes. Approximately a third of the country reports mentioned the use of wild-harvested plants. Nigeria, for example, cited the use of African mango (*Irvingia gabonensis*) and locust bean (*Parkia biglobosa*) in times of food shortage.

Grassland and forage species are another important component of agrobiodiversity, especially in countries where livestock production is a major contributor to the national economy.[2] FAO (2007) reports that natural grasslands are seriously degraded in many parts of the world, resulting in a need for greater attention to be devoted to *in situ* conservation in such ecosystems.

With the development of new biotechnological methods, CWR are becoming increasingly important in crop genetic improvement. Taking a broad definition of CWR as any taxon belonging to the same genus as a crop, it has been estimated that there are 50-60,000 CWR species worldwide.[3] Of these, approximately 700 are considered of highest priority, being the species that comprise the primary and secondary genepools of the world's most important food crops of which many are included in Annex 1 of the ITPGRFA.

2.2.1 Inventory and state of knowledge

Since the publication of the first SoW report, most countries have carried out specific surveys and inventories, either as part of their National Biodiversity Action Plans[4] or, more commonly, within the framework of individual projects. Most have been limited to single crops, small groups of species or to limited areas within the national territory.[5] For example, in Senegal inventories were made of selected species of fonio, millet, maize, cowpea and some leafy vegetables. Mali reported carrying out 16 inventories and surveys of 12 crops, and Malaysia and Albania have both conducted inventories of wild fruit species.

Very little survey or inventory work has been carried out on PGRFA in protected areas compared to other components of biodiversity in these areas.[6] The observation made in the first SoW report remains valid, i.e. that *in situ* conservation of wild species of agricultural importance occurs mainly as an unplanned result of efforts to protect particular habitats or charismatic species. While many countries assume that PGRFA, including CWR, are conserved by setting aside protected areas,[7] the reality is that in many countries this tends to fall between the cracks of two different conservation approaches – ecological and agricultural - the former focusing mainly on rare or threatened wild species and ecologies and the latter mainly on the *ex situ* conservation of domesticated crops. As a result, the conservation of CWR has been relatively neglected.[8] In an effort to redress this situation a global project, supported by the United Nations Environment Programme (UNEP)/Global Environment Facility (GEF) and led by Bioversity International, has been initiated with the aim of promoting collaboration between the environment and agriculture sectors in order to prioritize and conserve CWR in protected areas (see Box 2.1).

Compared to the first SoW report in which only four countries[9] reported that they had surveyed the status of CWR, the past decade has seen significant progress in this area, with CWR inventories compiled in at least 28 countries. Some also reported that specific sites for *in situ* conservation of CWR had been identified.[10] Jordan, Lebanon, the Palestinian Authority and Syria in collaboration with ICARDA have conducted surveys over the period 1999-2004 to assess the density, frequency and threats to wild relatives of cereals, food legumes, forage legumes and of seven genera of fruit trees and neglected species.

At the regional and global level, efforts have been made by several international organizations to carry out inventories and to determine the conservation status of wild plants. An analysis of the International Union for the Conservation of Nature's (IUCN) Red List of Threatened Species[11] shows that of the14 important crops for food security, as identified in the thematic study, (banana/plantain, barley, cassava, cowpea, faba bean, finger millet, garden pea, maize, pearl millet, potato, rice, sorghum, sweet potatoes and wheat), only 45 related wild species have been globally assessed, the majority of which are relatives of the potato.[12] The IUCN Species Survival Commission (SSC) has established a new Crop Wild Relative Specialist Group to support and promote the conservation and use of CWR. The Botanic Garden Conservation International (BGCI) has made an inventory of all CWR occurring in botanical gardens, and has added a CWR flag in its plant database.[13] The most comprehensive inventory of CWR is the catalogue for Europe and the Mediterranean,[14] which lists over 25,000 species of CWR that occur in the Euro-Mediterranean region. As a first step towards the creation of a European inventory of *in situ* CWR populations, the

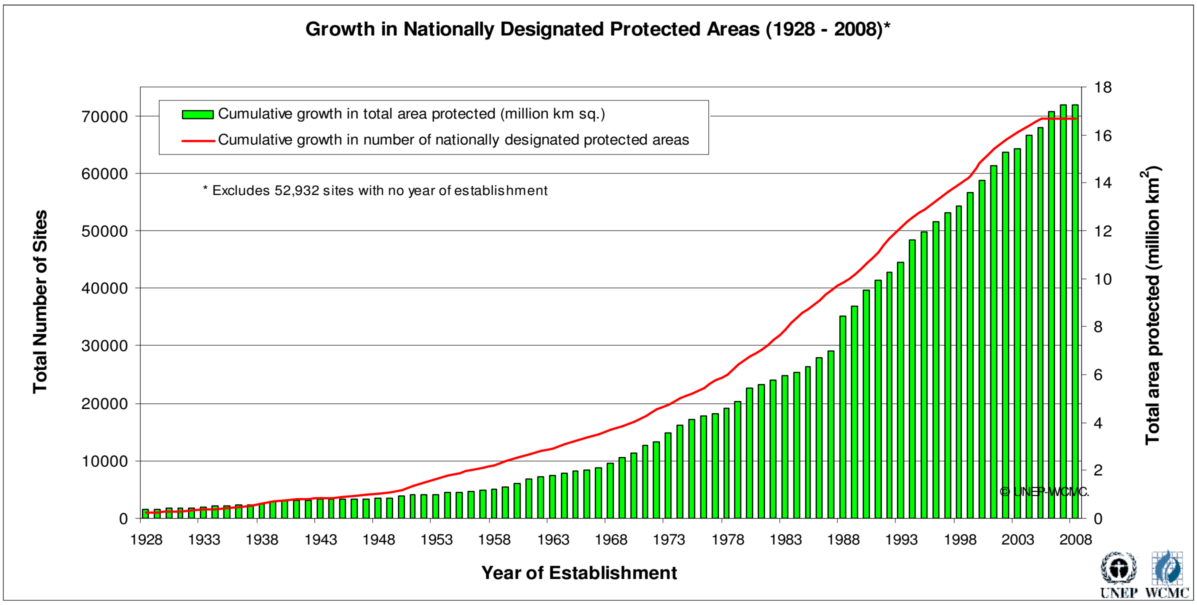
ECPGR has called for focal points to be appointed with responsibility for developing national *in situ* inventories.[15]

Many of the country reports have listed major obstacles to systematic national inventorying and surveying of PGRFA. These include: lack of funding, lack of human resources, skills and knowledge,[16] lack of coordination and unclear responsibilities,[17] low national priority,[18] inaccessibility of *in situ* areas,[19] and difficulties in obtaining necessary permissions.

2.2.2 In situ conservation of crop wild relatives in protected areas

The number of protected areas in the world has grown from approximately 56,000 in 1996 to about 70,000 in 2007, and the total area covered has expanded in the same period from 13 to 17.5 million km^2 (see Figure 1).[20] This expansion is reflected at the national level with most countries reporting an increase in the area protected. Paraguay, for example, has increased its protected area from 3.9% to 14.9% of the country's territory and Madagascar has pledged that one third of its territory will be protected by 2008.[21]

Figure 2.1: Growth in nationally designated protected areas (1928-2008)



(Source: World Database on Protected Areas (WDPA)[22].

The chart shows cumulative growth in nationally designated protected areas (marine and terrestrial) in both total number of sites and total area protected (km2) from 1928 - 2008. Only sites that are designated and have a known year of establishment have been included.

In an assessment of the extent to which wild PGRFA is actually conserved in protected areas[23] it was observed that, in general, areas with the greatest diversity (centres of origin and/or diversity) received significantly less protection than the global average. Most countries have less than 5% of their areas under some form of protection.

Since the last report, there has been a substantial increase in the number of articles published describing the status of CWR[24] and drawing attention to specific action needed.[25] However, few of the recommendations have been implemented, due largely to a lack of funds and appropriately skilled personnel (see section 2.5).

A recent study of the current status and trends in conservation of CWR in 40 countries[26] has shown that conservation activities can take many forms including field or database inventories and mapping;[27] ecogeographic surveys;[28] investigation of policy structures and decision-making;[29] studies of traditional and indigenous ethnobiology;[30] and monitoring of CWRs once management plans have been adopted.[31]

While a global survey of *in situ* conservation of wild PGRFA,[32] as well as an analysis of the country reports reveal that relatively few countries have been active in conserving PGRFA in protected areas, some progress has been made as the following examples show:

- Crop wild relatives are actively conserved in at least one protected area in each of the five countries of the CWR project coordinated by Bioversity International: Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan (see Box 2.1);
- In Ethiopia, wild populations of *Coffea arabica* are being conserved in the montane rainforest and studies are being carried out to assess the extent of Ethiopian coffee genetic diversity and its economic value. The aim is to develop models for conserving *C. arabica* genetic resources both within and outside protected areas;[33]
- Mali reported that wild fruit trees important for food security are managed in protected forests, and in southern Tanzania special conservation methods are used to manage the indigenous fruit tree *Uapaca kirkiana*;
- In Guatemala, priority conservation areas have been recommended for 14 'at risk' species including *Capsicum lanceolatum, Carica cauliflora, Phaseolus macrolepis, Solanum demissum* and *Zea mays* subsp. *huehuetenangensis*;[34]
- The Sierra de Manantlán Reserve in Southwest Mexico has been established specifically for the conservation of the endemic perennial wild relative of maize, *Zea diploperennis*;
- In the Asia and the Pacific region, a comprehensive conservation project on native tropical fruit species, including mango, citrus, rambutan, mangosteen, jackfruit and litchi, was implemented by ten Asian countries with technical support from Bioversity International.[35] In China, 86 *in situ* conservation sites for wild relatives of crops had been established by the end of 2007 and a further 30 sites planned. In Vietnam, *Citrus* spp. are included in six Gene Management Zones (GMZs) and in India, sanctuaries have been established in the Garo Hills of Meghalaya to conserve the rich native diversity of wild *Citrus* and *Musa* species;[36]
- In Europe, surveys have been carried out on wild *Prunus* species[37] and wild apples and pears.[38] The European Crop Wild Relative Diversity Assessment and Conservation Forum[39] has established *in situ* conservation methodologies for CWR[40] with the aim of promoting genetic reserves for crop complexes such as those of *Avena*, *Beta*, *Brassica* and *Prunus* species.
- The Erebuni Reserve has been established in Armenia to conserve populations of cereal wild relatives (*Triticum araraticum, T. boeoticum, T. urartu, Secale vavilovii* and *Hordeum spontaneum*)[41] and in Germany, the Flusslandschaft Elbe Biosphere Reserve is important for *in situ* conservation of wild fruit crop genetic resources and perennial ryegrass (*Lolium perenne*).
- In West Asia, in addition to the protected area established in Turkey for conserving wild relatives of cereals and legumes, in 2007 Syria established a protected area at Alujat and has banned the grazing of small ruminants in Sweida region to contribute to conserving wild relatives of cereals, legumes and fruit trees.

In spite of the above examples and the overall increase in the number of protected areas, the range of genetic diversity of target species within them remains inadequately represented, and many of the ecological niches that are important for wild PGRFA remain unprotected. In a study of wild peanut (*Arachis* spp.) in South America, it was found that the current conservation areas poorly cover the distribution of the species, with only 48 of the 2,175 geo-referenced observations included in the study originating from National Parks.[42]

2.2.3 In situ conservation of PGRFA outside protected areas

A World Bank study[43] reported that while existing parks and protected areas are the cornerstones of biodiversity conservation, they are insufficient to ensure the continued existence of a vast proportion of tropical biodiversity. A significant number of wild PGRFA species, for example, occur outside conventional protected areas and consequently do not receive any form of legal protection.[44] Cultivated fields, field margins, grasslands, orchards and roadsides may all harbour important CWR and other useful wild plants. Plant diversity in such areas faces a variety of threats including the widening of roads, removal of hedgerows or orchards, overgrazing, expansion in the use of herbicides or even just different regimes for the physical control of weeds.[45]

The effective conservation of PGRFA outside protected areas requires that social and economic issues be addressed. This may require, for example, specific management agreements to be concluded between owners of prospective sites and conservation agencies. Such agreements are becoming more common in North America and Europe. Micro-reserves have been established in the Valencia region of Spain.[46] In Peru farming communities have signed an agreement with the International Potato Centre (CIP) to establish a 15,000 ha 'Potato Park' near Cusco where the genetic diversity of the region's numerous potato varieties is protected by local indigenous people who own the land and who are also allowed to control access to these local genetic resources.

Many CWR species grow as weeds in agricultural, horticultural and silvicultural systems, particularly those associated with traditional cultural practices or marginal environments. In many areas such species may be particularly threatened as a result of the move away from traditional cultivation systems. Several national governments in developed countries[47] now provide incentives, including financial subsidies, to maintain these systems and the wild species they harbour. While such options are largely unaffordable and unenforceable throughout most of the developing world, opportunities do exist for integrating the on farm management of landraces and farmer varieties with the conservation of CWR diversity.[48] Several countries in West Africa commented on the important role of local communities and traditional methods in the sustainable management of grassland ecosystems.

While several country reports mention that measures have been taken to support *in situ* conservation outside of protected areas (e.g. Guinea Conakry), details have rarely been provided. In Vietnam, a research project on *in situ* conservation of landraces and CWR outside the protected areas aimed to conserve globally significant agro-biodiversity of rice, taro, litchi, longan, citrus and tea, at 11 sites in 7 provinces. The strategy was to promote community-based Plant Genetic Resources Important Zones (PGR-IZs). In Germany, the '100 fields for biodiversity'[49] project focuses on the conservation of wild plant species (including CWR) outside of protected areas through establishing a nationwide conservation field network for wild arable plant species. Research in West Asia has found significant CWR diversity in cultivated areas, especially at the margins of fields and along roadsides.[50] It has also been reported that in Jabal Sweida in Syria, rare wheat, barley, lentil, pea and faba bean CWR are common in modern apple orchards.[51]

Table 2.1 Summary of 14 priority crop wild relative species

Crop	High priority CWRs	Centers of diversity	Likely occurrence inside PA	Known occurrence inside PA	Known occurrence outside PA	Countries in which suggested priority site/areas should be located	Suggested sites are specific protected areas or in their vicinity? (Y/N)
Finger millet (*Eleusine coracana)*	*E. intermedia*	East Africa	x			Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Uganda	Y
	E. kigeziensis		x		x		Y
Barley *(Hordeum vulgare)*	*H. chilense*	Main: South-western Asia; Others: Central Asia, southern South America, western North America	x		x	Chile	Y
Sweet potato *(Ipomoea batatas)*	*I. batatas* var. *apiculata*	Main: North-western South America Others: Indonesia, Papua New Guinea, Sub-Saharan Africa	x			Mexico	Y
	I. tabascana				x		N
Cassava *(Manihot esculenta)*	*M. alutacea* *M. foetida* *M. leptopoda* *M. neusana* *M. oligantha* *M. peltata* *M. pilosa* *M. pringlei* *M. tristis*	Brazil, Bolivia, Latin America				Brazil	N
Banana/plantain *(Musa acuminate)*	*M. basjoo* *M. cheesmani* *M. flaviflora* *M. halabanensis* *M. itinerans* *M. nagensium* *M. ochracea* *M. schizocarpa* *M. sikkimensis* *M. textilis*	India, Malaysia				Bhutan, India, Papua New Guinea, Sumatra, Philippines	N
Rice *(Oryza sativa)*	*O. longiglumis* *O. minuta*	Asia, Pacific, Africa		x		India, Papua New Guinea, Sri Lanka	Y
	O. rhizomatis			x	x		Y
	O. schlechteri		x		x		Y

Pearl millet *(Pennisetum glaucum)*	*P. schweinfurthii*	Western Africa	x		x	Sudan	Y
Garden pea *(Pisum sativum)*	*P. abyssinicum* *P. sativum* subsp. *elatius* var. *brevipedunculatum*	Ethiopia, Mediterranean, central Asia			x	Cyprus, Ethiopia, Syria, Turkey, Yemen	N
Potato *(Solanum tuberosum)*	110 species with 5 or fewer observation records[52]	South-central Mexico, South America				Argentina, Bolivia, Ecuador, Mexico, Peru	N
Sorghum *(Sorghum bicolor)*	none	Southeast Asia, India, South America, Africa					
Wheat *(Triticum aestivum)*	*T. monococcum* subsp. *aegilopoides* *T. timopheevii* subsp. *armeniacum* *T. turgidum* subsp. *paleocolchicum* *T. turgidum* subsp. *dicoccoides* *T. turgidum* subsp. *polonicum* *T. turgidum* subsp. *turanicum* *T. urartu* *T. zhukovskyi*	Transcaucasia, Fertile Crescent, Eastern Mediterranean			x	Georgia, Iran, Iraq, Lebanon, Turkey	N (except one)
Faba bean *(Vicia faba*	*V. eristalioides*	Mediterranean		x		Syria, Turkey	Y
	V. faba subsp. *paucijuga* *V. galilaea* *V. hyaeniscyamus* *V. kalakhensis*				x		N
Cowpea *(Vigna unguiculata)*	*V. unguiculata* • subsp. *aduensis* • subsp. *alba* • subsp. *baoulensis* • subsp. *burundiensis* • subsp. *letouzeyi* • subsp. *unguiculata* var. *spontanea*	India/Southeast Asia; Tropical Africa			x	Numerous African countries	Y
	V. unguiculata • subsp. *pawekiae* • subsp. *pubescens*			x			
Maize *(Zea mays)*	*Z. luxurians*	Mexico	x		x	Guatemala, Nicaragua	Y / N
	Z. mays subsp. *huehuetenangensis*				x	Guatemala	
	Z. diploperennis			x		Mexico	

Source: Maxted, N. and S.P. Kell, 2009. Establishment of a Global Network for the *In Situ* Conservation of Crop Wild Relatives: Status and Needs. FAO Commission on Genetic Resources for Food and Agriculture. Rome, Italy. 266 pp.

2.2.4 Global system for in situ conservation areas

The first SoW report recommended the establishment of a system of *in situ* conservation areas and the development of guidelines for site selection and management. In response, the CGRFA commissioned a study[53] on the establishment of a global network for the *in situ* conservation of CWR. The study report proposed conservation priorities and specific locations in which to conserve the most important wild relatives of 14 of the world's major food crops (see Table 2.1). The report points out that about 9% of the CWR of the 14 crops require urgent conservation attention. A brief summary of the regional priorities presented in the report is given below:

Africa
High priority locations have been identified in Africa for the conservation of wild relatives of finger millet (*Eleusine* spp.), pearl millet (*Pennisetum* spp.), garden pea (*Pisum* spp.) and cowpea (*Vigna* spp.).

Americas
In the Americas, priority locations for genetic reserves have been identified for barley (*Hordeum* spp.), sweet potato (*Ipomoea* spp.), cassava (*Manihot* spp.), potato (*Solanum* spp.) and maize (*Zea* spp.).

Asia and the Pacific
Potential genetic reserve locations have been identified for the four highest priority taxa of wild rice (*Oryza* spp.) and ten priority taxa related to cultivated banana/plantain (*Musa* spp.).

Near East
The highest priority locations for conserving the wild relatives of garden pea (*Pisum* spp.), wheat (*Triticum* spp. and *Aegilops* spp.), barley (*Hordeum spontaneum* and *H. bulbosum*) and faba bean (*Vicia* spp.) occur in this region.

These highest priority sites provide a good basis for establishing a global network of CWR genetic reserves, in line with the draft Global Strategy for Crop Wild Relative Conservation and Use[54] developed in 2006.

2.3 On farm management of PGRFA in agricultural production systems

The on farm management and conservation of PGRFA, in particular the maintenance of traditional crop varieties in production systems, has gained much ground since the first SoW report was published. Many new national and international programmes have been set up around the world to promote on farm management and the published literature over the last ten years has resulted in there being a clearer understanding of the factors that influence it.[55] New tools have been developed that enable this diversity, and the processes by which it is maintained, to be more accurately assessed and understood[56] and there is a better understanding of the complementarities between *in situ*/on farm and *ex situ* conservation. However, relatively little is still known about how to achieve the best balance in the use of these two approaches, or about the dynamic nature of that relationship. The country reports provided information, summarized below, on the extent and distribution of crop genetic diversity within agricultural production systems, the management processes that have maintained this diversity, the national capacity to support the maintenance of diversity, and progress in on-the-ground conservation interventions.

2.3.1 Amount and distribution of crop genetic diversity in production systems

Efforts to measure genetic diversity within production systems have ranged from the evaluation of plant phenotypes using morphological characters, to the use of new tools of molecular biology. Considerable variation exists among production systems and many country reports pointed out that the highest levels of crop genetic diversity occurred most commonly in areas where production is particularly difficult, such as in desert margins or at high altitudes, where the environment is extremely variable and access to resources and markets is restricted.

Little information was available from country reports regarding actual numbers of traditional varieties maintained on farm. The Georgia country report mentioned that 525 indigenous grape varieties are still being grown in the mountainous countryside and isolated villages, while in the Western Carpathians of Romania, more than 200 local landraces of crops have been identified.

In contrast, the published literature since the first SoW report contains a wealth of information on numbers of traditional varieties grown on farm. A major conclusion from these publications is that a significant amount of crop genetic diversity in the form of traditional varieties continues to be maintained on farm even through years of extreme stress.[57] In a study in Nepal and Vietnam of whether traditional rice varieties are grown by many households or only a few, and over large or small areas,[58] it was found that more than 50% of traditional varieties are grown by only a few households on relatively small areas.

Farmers' variety names can provide a basis for estimating the actual numbers of traditional varieties occurring in a given area and, more generally, as a guide to the total amount of genetic diversity. However, different communities and cultures approach the naming, management and distinguishing of local cultivars in different ways and no simple, direct relationship exists between cultivar identity and genetic diversity.[59]

2.3.2 Management practices for diversity maintenance

Practices that support the maintenance of diversity within agricultural production systems include agronomic practices, seed production and distribution systems as well as the management of the interface between wild and cultivated species.

A widespread system that conserves a wealth of traditional varieties is production in home gardens. Cuba, Guatemala, Ghana, Indonesia, Venezuela and Vietnam all reported that significant crop genetic diversity exists in home gardens, which can act as refuges for crops and crop varieties that were once more widespread. Farmers often use home gardens as a site for experimentation, for introducing new cultivars, or for the domestication of wild species. Useful wild species may be moved into home gardens when their natural habitat is threatened, e.g. through deforestation, as in the case of loroco (*Fernaldia pandurata*) in Guatemala.[60]

A recent review[61] revealed that traditional crop varieties and landraces of horticultural crops, legumes and grains are still extensively planted by farmers and gardeners throughout Europe, and they are often found in the home gardens of rural households. Invaluable diversity of traditional varieties of many crops, especially of fruits and vegetables but also of maize and wheat, is still available, even in countries where modern commercial varieties dominate the seed systems, crop fields, and commercial orchards.

Many country reports have indicated that 'informal' seed systems remain a key element in the maintenance of crop diversity on farm (see Chapter 4.4) and can account for up to 90% of seed movement.[62] While seed exchange can take place over large distances, in many cases it appears to be more important locally, especially within traditional farming systems. In Peru, for example, between 75 and 100% of the seed used by farmers in the Aguaytia valley was exchanged within the community with little going outside.[63]

Access to seeds of traditional varieties can be an issue in some developed countries. In the EU, for example, only certified seed of officially registered varieties can be marketed commercially, although local, small-scale non-commercial exchange of planting material remains quite common. However, the new EU directive 2008/62/EC provides for a certain flexibility in the registration and marketing of traditional landraces and varieties, so-called 'conservation varieties'. For more information on seed legislation and its impacts see Chapter 5.4.2.

Several countries report on how the genetic make-up of local varieties depends on the effects of both natural selection and selection by farmers. In Mali, studies have shown that local varieties of sorghum collected in 1998 and 1999 matured 7–10 days earlier than those collected 20 years earlier, as the result of natural selection, farmer selection, or both. This underlines the dynamic nature of *in situ* management – it results in the conservation of many components of the genetic makeup of the varieties concerned, but also allows genetic change to occur.

Farmer seed selection practices vary widely. They may select seeds from plants growing in a certain part of the field, from particularly 'healthy' plants, from a special part of the plant, from plants at different stages of maturity, or they may simply take a sample of seed from the overall harvest. In some local communities in Ouahigouya, Burkina Faso, for example, pearl millet farmers harvest seed from the center of the field to maintain 'purity', selecting a range of types and taking into account uniformity of grain color and spikelet dehiscence. This practice appears to favor seed quality and seed vigor.[64]

The Cyprus and Greece country reports indicated that many farmers in these countries prefer to save their own seeds and when replaced, the same variety is generally obtained from a relative, neighbour, or the local market (commonly in that order of preference). In this way, over a period of years much mixing occurs. Community genebanks have also been established in a number of countries[65] and can be important sources of seeds for local farmers.

A sharp decrease in the number of farmers growing a particular variety can create genetic bottlenecks that may be associated with loss of genetic diversity. This can occur as a result of natural disasters, war or civil strife when local seed availability may be severely reduced. Seed and other propagating materials may be lost or eaten, supply systems disrupted and seed production systems destroyed (see Chapter 1). At the same time relief organizations may distribute seed of new cultivars that can result in further changes in the number and type of varieties grown.

The interface between wild and agricultural plants and ecosystems is highly complex and can result in both positive and negative effects regarding the maintenance of genetic diversity. The natural introgression of new genes into crops can expand the diversity available to farmers. Geneflows between crop cultivars and their wild relatives has been a significant feature of the evolution of most crop species[66] and it continues to be important today.[67] In Benin and other West African countries, for example, it has been reported that introgression between wild and domesticated yams is important in the continuing improvement of yam cultivars by farmers.[68]

Several country reports provide examples of the management of the crop-wild interface. In southern Cameroon, for example, wild yams (*Dioscorea* spp.) are important as a food and in the culture of the Baka Pygmies. Through a variety of technical, social and cultural practices, referred to as ‘paracultivation’, they are able to make use of the wild resources while keeping them in their natural environment. In Tajikistan, superior genotypes of walnut (*Juglans regia*) and pistachio (*Pistacia vera*) have been selected from the wild and are now in cultivation, and wild apples have been planted in orchards in some parts of the Pamir mountain range. In Jordan and Syria, natural gene flows between cultivated and wild *Triticum* species were confirmed using morphological and molecular techniques.[69]

2.3.3 Farmers as custodians of diversity

During the last decade extensive work has been carried out to better understand why and how farmers continue to maintain diversity on farm. This has resulted in a better appreciation of the range of custodians, the role of traditional knowledge and the needs and choices farmers have within their livelihood systems. The diversity of stakeholders who maintain and use PGRFA has been looked at in many countries. Work in China, and Nepal, for example, has found that only one or two expert farmers in a given community account for the maintenance of most of the diversity.[70] Age, gender, ethnic group and wealth status all have a bearing on who maintains diversity, what diversity is maintained and where. Especially in developed countries, individuals may be involved for hobby or other non-commercial reasons. Japan has implemented a system to recognize and register people as leaders in the cultivation of local crops, based on their experience and technical capabilities.

Many country reports recognize the importance of traditional knowledge in the conservation and use of PGRFA on farm. Bangladesh, Ethiopia, India, Kazakhstan, Lao PDR and Tanzania all describe efforts to document and protect indigenous knowledge, while many others state the need to do so (Cyprus, Finland, Malaysia, Philippines and Sri Lanka) or for appropriate policies to this end (Thailand and Zambia).

Many factors influence the choice of how many and which varieties to grow and on what area, including the need to minimize risk, maximize yields, ensure nutritional balance, spread workloads and capture market opportunities. A series of empirical studies in Burkina Faso, Hungary, Mexico, Nepal, Uganda and Vietnam suggested that major factors affecting varietal choice also include market access, seed supply, farmer age and gender and whether the variety is common or rare.[71]

2.3.4 Options to support the conservation of diversity in agricultural production systems

While there are many ways in which farmers can benefit from a greater use of local crops and varieties, in many cases action is needed to make them more competitive with modern varieties and major crops. Potential interventions to increase competitiveness include: better characterization of local materials, improvement through breeding and processing, greater access to materials and information, promoting increased consumer demand, and more supportive policies and incentives. In many cases efforts to implement such interventions are led by NGOs that may or may not be linked to national research and education institutes.

Adding value through characterizing local materials: While work has been carried out in a number of countries on characterization of local materials, landraces are often inadequately characterized, especially under on farm conditions. There is some indication from the country reports that greater efforts have been devoted to characterizing traditional and local varieties over the past decade. The Czech Republic reports that state financial support is available for the evaluation of neglected crops.

Improving local materials through breeding and seed processing: Improvement of local materials can be achieved through plant breeding or through the production of better quality seed or planting material. Since the first SoW report, particular attention has been given to participatory approaches to crop evaluation, improvement and breeding, especially involving local farmer varieties (see Chapter 4). Several case studies have been conducted by the ECPGR Working Group on on farm conservation and management. These relate to cowpea and beans in Italy, Shetland cabbage in Scotland, fodder beets in Germany, Timothy grass in Norway and tomato in Spain.[72]

Increasing consumer demand through market incentives and public awareness: Raising public awareness of local crops and varieties can help build a broader base of support. This can be achieved in many ways, for example through personal contacts, group exchanges, diversity fairs, poetry, music and drama festivals, and the use of local and international media.[73] Albania, Malaysia, Namibia, Nepal, Pakistan, Portugal, Philippines and Thailand all reported on the establishment of markets and fairs for the promotion of local products. Other ways of income generation include promoting ecotourism and branding products with internationally accepted certificates of origin or the like for niche markets.[74] In Jamaica, on farm management is supported by the development of local and export markets for a wide range of traditional and new products originating from local under-utilized crops. Malaysia, likewise, reported on efforts to develop commercial value-added, 'diversity-rich' products.

Improved access to information and materials: The importance of maintaining and managing information and knowledge about diversity at the community or farmer level is recognized in many country reports. A number of initiatives have been developed through the NGO community, which aim to strengthen indigenous knowledge systems, for example ‘Community Biodiversity Registers’ in Nepal, that record information on the cultivars grown by local farmers.[75] Ethiopia, Nepal, Peru and Vietnam all report that ‘diversity fairs’ allow their farmers to see the extent of diversity available in a region and to exchange materials. These have proven to be a popular and successful way of strengthening local knowledge and seed supply systems.[76] In Finland, the project ‘ONFARMSUOMI: Social and cultural value, diversity and use of Finnish landraces’ aims to find new ways to encourage the on-farm management of traditional crop diversity. It has developed a web based ‘landrace information bank’ to encourage and support the cultivation of landraces among farmers as well as to enhance awareness among the general public.

Supportive policies, legislation and incentives: Traditional varieties are generally dynamic and evolving entities, characteristics that need to be recognized in any policies designed to support their maintenance. Recent years have seen several countries enact new legislation that aims to support the use of traditional varieties. In Cyprus, the Rural Development Plan 2007-2013 is the main policy instrument covering the on farm management of PGRFA. It contains a range of different measures to promote the conservation and use of diversity in agricultural and forest land within protected areas. In Hungary the National Agri-Environment Programme (NAEP) has adopted a system of Environmentally Sensitive Areas (ESA) through which areas of low agricultural productivity but high environmental value are designated for special conservation attention. (For a more extensive discussion of policy issues in relation to the conservation and use of PGRFA see Chapters 5 and 7.)

2.4 Global challenges to *in situ* conservation and management of PGRFA

The Millennium Ecosystem Assessment (MEA)[77] identified five major drivers of biodiversity loss: climate change, habitat change, invasive alien species, overexploitation and pollution. Of these, the first three arguably pose the greatest threat to PGRFA and are discussed in the following sections. In many countries the introduction of new varieties is also seen a significant factor in the loss of traditional crop diversity and is also discussed below.

2.4.1 Climate change

Many country reports[78] refer to the threat of climate change to genetic resources. All the predicted scenarios of the Intergovernmental Panel on Climate Change (IPCC)[79] will have major consequences for the geographic distribution of crops, individual varieties and CWR. Even the existing protected area system will require a serious rethink in terms of size, scale and management.[80] Wildlife corridors, for example, will become increasingly important to enable species to migrate and adjust their ranges. Small island states, which are often high in endemic species, are also highly vulnerable to climate change, particularly to rises in sea level.

A recent study[81] used current and projected climate data for 2055 to predict the impact of climate change on areas suitable for a number of staple and cash crops. A picture emerged of a loss of suitable areas in some regions including many parts of Sub-Saharan Africa (SSA) and gains in other regions. Of the crops studied, 23 were predicted to gain in terms of overall area suitable for production at the global level while 20 were predicted to lose. Another study predicted similar trends[82] including the overall loss of suitable land and potential production of staple cereal crops in SSA. Many developed nations, on the other hand, are likely to see an expansion of suitable arable land into latitudes further away from the equator.

2.4.2 Habitat change

The expansion of agriculture itself, in large part due to the direct and indirect effects of an increasing, and increasingly urbanized human population, is one of the biggest threats to the conservation of wild genetic diversity of agricultural importance. The MEA reported that cultivated land covers one quarter of the Earth's terrestrial surface and that while the cropped areas in North America, Europe and China have all stabilized since 1950, this is not true in many other parts of the world. A further 10–20% of land currently under grass or forest will be converted to agriculture by 2050. Some countries, e.g. Argentina and Bolivia, specifically refer to the expansion of land devoted to agriculture as a major threat to CWR.

2.4.3 Invasive alien species

The MEA cited invasive alien species, including pest and disease organisms, as one of the biggest threats to biodiversity. While the problem may be particularly severe on small islands, several continental countries, including Bosnia and Herzegovina, Nepal, Slovak Republic and Uganda, also specifically reported this as a threat to wild PGRFA. The problem has been exacerbated in recent years due to increased international trade and travel. Many small island developing states now have to confront huge problems of biological invasion. St Helena, Jamaica, Mauritius, Seychelles, Pitcairn, French Polynesia and Reunion, are all among the top ten most affected countries based on the percentage of their total flora under threat.[83]

2.4.4 Replacement of traditional with modern varieties

The replacement by farmers of traditional varieties by new, improved modern varieties has been recognized as an issue in more than 30 of the country reports (see also Chapter 1). Georgia cites the example of local varieties of apples and other fruits being replaced by introduced modern varieties from abroad. Pakistan reports that the release of high yielding varieties of chickpea, lentil, mung bean and blackgram have resulted in the loss of local varieties from farmers' fields.

2.5 Changes since the first SoW report was published

The first SoW report emphasized the need to develop specific conservation measures for CWR and wild food plants, particularly in protected areas; sustainable management systems for rangelands, forests and other humanized ecosystems; and systems for the conservation and sustainable use of landraces or traditional crop varieties on farm and in home gardens. While there is good evidence of progress over the past decade in developing tools to support the assessment, conservation and management of PGRFA on farm, it is less evident that the *in situ* conservation of wild relatives has advanced as significantly, especially outside of protected areas. The following summarizes the major trends and developments since the first SoW report:

- A large number of surveys and inventories of PGRFA have been conducted;
- The *in situ* conservation of PGRFA (in particular CWR) in wild ecosystems still occurs mainly in protected areas. Less attention has been given to conservation elsewhere. There has been a significant increase in the number and coverage of protected areas;
- CWR have received much more attention. A global strategy for CWR conservation and use has been drafted, protocols for the *in situ* conservation of CWR are now available, and a new Specialist Group on CWR has been established within IUCN/SSC;
- While many countries have reported an increase in the number of *in situ* and on farm conservation activities, they have not always been well coordinated;
- There has been little progress on the development of sustainable management techniques for plants harvested from the wild, which are still largely managed following traditional practices;
- The last decade has seen an increase in the use of participatory approaches and multi-stakeholder teams implementing on farm conservation projects;

- A number of new tools, especially in the area of molecular genetics, have become available and training materials have been developed for assessing genetic diversity on farm;
- New legal mechanisms enabling farmers to market genetically diverse varieties, coupled with legislation supporting the marketing of geographically identified products have provided additional incentives for farmers to conserve and use local crop genetic diversity in a number of countries;
- Significant progress has been made in understanding the value of local seed systems and in strengthening their role in maintaining genetic diversity on farm;
- There is evidence that more attention is now being paid to increasing the levels of genetic diversity within production systems as a means of reducing risk, particularly in the light of the predicted effects of climate change.

2.6 Gaps and needs

An analysis of the country reports, regional consultations and thematic reports identified a number of gaps and needs to improve *in situ* conservation and on farm management of PGRFA. While the major issues identified in the first SoW report remain (lack of skilled personnel, financial resources, and appropriate policies) a few new needs have also been identified.

- The draft global strategy on the conservation of CWR needs to be finalized and adopted;[84]
- There is a need to strengthen the ability of farmers, indigenous and local communities and their organizations, as well as extension workers and other stakeholders, to sustainably manage agricultural biodiversity;
- There is a need for more effective policies, legislation and regulations governing the *in situ* and on farm management of PGRFA, both inside and outside of protected areas. There is a need for closer collaboration in this, especially between the agriculture and environment sectors;
- There is a need for specific strategies to be developed for conserving PGRFA *in situ* and for managing crop diversity on farm. Special attention needs to be given to conservation of CWR in their centres of origin, major centres of diversity and biodiversity hotspot areas;
- The involvement of local communities is essential in any *in situ* conservation or on farm management effort and traditional knowledge systems and practices need to be fully taken into account. Collaboration between all stakeholders needs to be strengthened in many countries;
- There is a need in all countries to develop and put in place early warning systems for genetic erosion;
- Strengthened research capacity is required in many areas, and in particular in conducting inventories and surveys using new molecular tools;
- Specific research needs relating to on farm management or *in situ* conservation of PGRFA include:
    - Studies on the extent and nature of possible threats to existing diversity on farm and *in situ*;

- The need for a better understanding of the role of PGRFA in providing ecosystem services and how this role can be strengthened;

- The need for better inventories and characterization data on land races and CWR;

- Ethnobotanical and socio-economic studies, including the study of indigenous and local knowledge, to better understand the role and limits of farming communities in the management of PGRFA;

- Studies of the effectiveness of different mechanisms for managing genetic diversity and how to improve them;

- Studies of the dynamic balance between *in situ* and *ex situ* conservation. What combination works best, where, under what circumstances, and how should the balance be determined and monitored;

- Studies on the mechanisms, extent, nature and consequences of geneflow between wild and cultivated populations;

- Further research to provide information to underpin the development of appropriate policies for the conservation and use of genetic diversity, including the economic valuation of PGRFA.

Box 2.1 A Crop Wild Relatives Project: Increasing knowledge, promoting awareness and enhancing action

The global project, '*In situ* conservation of crop wild relatives through enhanced information management and field application', supported by UNEP/GEF and coordinated by Bioversity International, has made significant advances in promoting the *in situ* conservation of CWR in protected areas. The project works in Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan and has sought to establish effective partnerships among stakeholders from both the agriculture and environment sectors. The project has comprehensively assessed threats to CWR and identified activities for their mitigation. Outputs have included the development of CWR national action plans; management plans for specific species and protected areas; guidelines for conserving CWR outside protected areas; and improved legislative frameworks for CWR conservation. Selected species of CWR have been evaluated to identify traits of value in crop improvement. Information from the project has been integrated within national information systems and is available through a Global Portal. This, combined with training and innovative public awareness efforts, means that the project is helping enhance the conservation of CWR not only in the participating countries but also throughout the world.

Box 2.2 Promoting in situ conservation of dryland agrobiodiversity in West Asia

In 1999 a five-year project was launched entitled 'Conservation and Sustainable Use of Dryland Agrobiodiversity'. It aimed to promote the *in situ* conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria, and focused on conserving landraces and wild relatives of barley, wheat, lentil, *Allium*, fodder legumes (*Lathyrus*, *Medicago*, *Trifolium* and *Vicia*) and fruit trees (including olive, fig, almond, pistachio, plum, peach, pear and apple). The project was funded by GEF/UNDP and coordinated by ICARDA in collaboration with Bioversity International and the Arab Center for the Study of Arid Zones and Dry Lands (ACSAD).

Eco-geographic surveys were conducted in 65 monitoring areas, and farming systems surveys were carried out in 26 communities in eight contrasting target areas (two for each country). The surveys showed that overgrazing and the destruction of natural habitats, especially through agricultural encroachment and urban spread, have reduced the distribution and density of wild species considerably. Geographical information systems and remote sensing techniques were used to confirm the survey data.

While landraces of wheat and most fruit trees are being replaced by improved varieties, in the case of barley, lentil, fig and olive, landraces still predominate, especially under harsh conditions. However the extent of their use is diminishing due to replacement by new species and varieties, mainly of fruit trees.

Populations of the wild relatives of wheat (*Triticum dicoccoides*, *T. urartu* and *T. boeoticum*) are also disappearing rapidly from the few remaining natural habitats where large populations were reported to exist before 1996. Sites for future *in situ* conservation action were identified and management plans were drawn up and presented to governments and key stakeholders. The plans included technological, socio-economic, institutional, and policy options.

Based on the findings of the project, afforestation programmes in the region began to include native tree species and wild relatives of fruit trees in their plantings, and informal seed systems and fruit tree nurseries were encouraged to supply landraces to local communities. The project also helped draft national agro-biodiversity policies and legislation and successfully introduced *in situ* conservation activities into the work of the Genetic Resources Units of the Ministries of Agriculture. The project also helped increase awareness of the importance of agrobiodiversity among decision makers, farmer communities and the general public, and since 2003 the conservation of biodiversity has been included in school curricula in all four countries.

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Chapter 3

The state of *ex situ* conservation

3.1 Introduction

Ex situ conservation continues to represent the most significant and widespread means of conserving PGRFA. Most conserved accessions are maintained in genebanks, either as seed in specially designed cold stores or, in the case of vegetatively propagated crops and crops with recalcitrant seeds, as living plants grown in the open in field genebanks. In some cases, tissue samples are stored *in vitro* or cryogenically and a few species are maintained as pollen or embryos. Increasingly scientists are also looking at the conservation implications of storing DNA samples or electronic DNA sequence information (see section 3.4.6 below).

Following a general overview of the status of genebanks around the world, this chapter addresses a number of facets of *ex situ* conservation: collecting, types of collection, security of conserved germplasm, regeneration, characterization and documentation, germplasm movement, and botanical gardens. It ends with a brief overview of the changes that have taken place since the first SoW report was published and an assessment of gaps and needs for the future.

3.2 Overview of genebanks

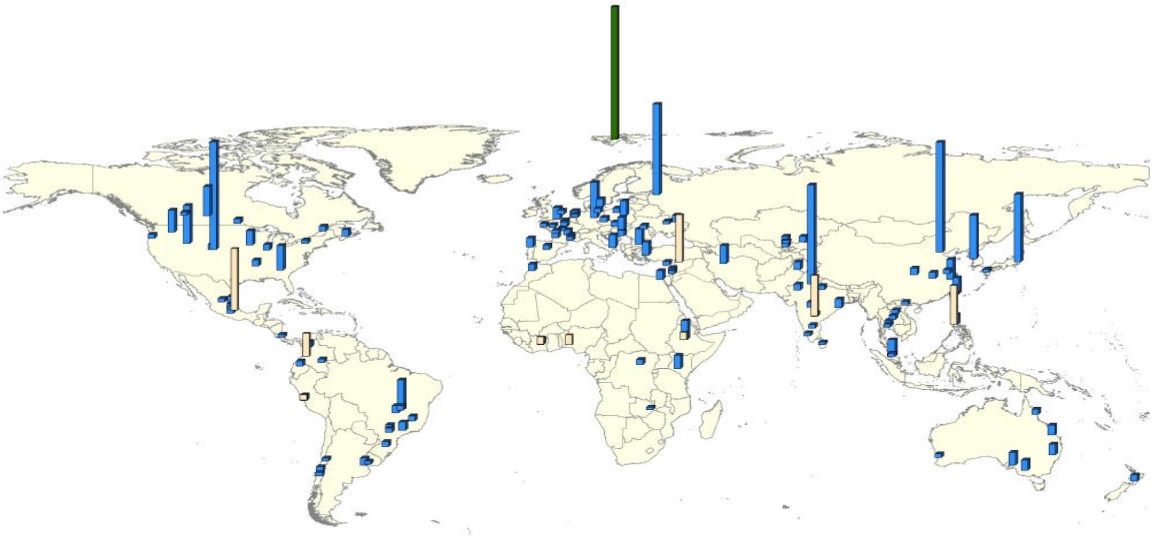
There are now more than 1,750 individual genebanks worldwide, about 130 of which hold more than 10,000 accessions each. There are also substantial *ex situ* collections in botanical gardens, of which there are over 2,500 around the world. Genebanks are located on all continents, but there are relatively fewer in Africa compared to the rest of the world. Among the largest collections are those that have been built up over more than 35 years by the CGIAR and are held in trust for the world community. In 1994 the Centres signed agreements with FAO bringing their collections within the International Network of *Ex Situ* Collections. These were subsequently brought under the International Treaty on Plant Genetic Resources for Food and Agriculture in 2006 (ITPGRFA - see Chapter 7).

Based on figures in WIEWS[1] and country reports, it is estimated that currently about 7.4 million[2] accessions are maintained globally, 1.4 million more than was reported in the first SoW report. Various analyses suggest that between 25% and 30% of the total holdings (or 1.9 - 2.2 million accessions) are distinct, with the remainder being duplicates held either in the same or, more frequently, a different collection.

Germplasm of crops listed under Annex I of the ITPGRFA is conserved in more than 1,240 genebanks worldwide and comprises a total of about 4.6 million samples.[3] Of these, about 51% is conserved in more than 810 genebanks of the Contracting Parties of the ITPGRFA and 13% is stored in the international collections of the CGIAR Centres. Of the total 7.4 million accessions, national genebanks conserve about 6.6 million, 45% of which is held in only seven countries[4] down from 12 countries in 1996. This increasing concentration of *ex situ* germplasm in fewer countries and research centers highlights the importance of mechanisms to ensure facilitated access, such as that of the multilateral system under the ITPGRFA.

The geographic distribution of accession stored in genebanks and as safety backup samples in the Svalbard Global Seed Vault is summarized in Figure 3.1 and Table 3.1.

Figure 3.1 Geographic distribution of genebanks with holdings of >10,000 accessions (national and regional genebanks (blue); CGIAR genebanks (beige); SGSV[5] (dark green)[6]



Source: WIEWS 2009; Country Reports; USDA-GRIN 2009

Table 3.1 Regional and sub-regional distribution of accessions stored in national genebanks (international and regional genebanks are excluded)

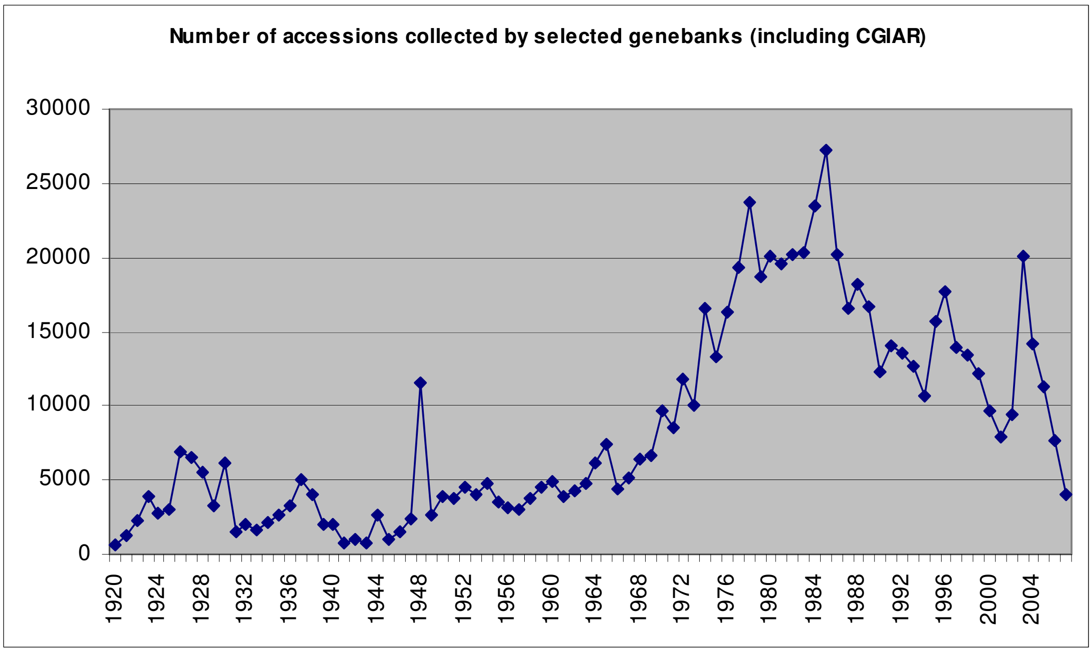
Region[7]	Sub-region	Number of accessions
Africa	East Africa	145,644
Africa	Central Africa	20,277
Africa	West Africa	96,891
Africa	Southern Africa	70,650
Africa	Indian Ocean Islands	4,604
Americas	South America	687,012
Americas	Central America and Mexico	303,138
Americas	Caribbean	33,115
Americas	North America	749,139
Asia and the Pacific	East Asia	1,039,134
Asia and the Pacific	Pacific	249,882
Asia and the Pacific	South Asia	714,562
Asia and the Pacific	Southeast Asia	309,835
Europe	Europe	1,735,407
Near East	South/East Mediterranean	141,015
Near East	Central Asia	153,849
Near East	West Asia	169,930

Source: WIEWS 2009 and Country Reports

3.3 Collecting

According to the country reports, the trends reported in the first SoW appear to have continued with respect to the decline in international germplasm collecting, an increase in national collecting and the greater importance now given to crop wild relatives. According to the country reports and on-line databases, more than 240,000 new accessions have been collected and added to *ex situ* genebanks over the period 1996-2007.[8] The large majority of missions collected germplasm of direct national interest, particularly obsolete cultivars, landraces and related wild species. Cereals, food legumes and forages were the main crop groups targeted. The number of accessions collected every year since 1920 and stored in selected genebanks[9], including those of the CGIAR, is illustrated in Figure 3.2. There was a gradual increase in the annual collecting rate between 1920 and the late 1960s and a rapid increase from then until the mid 1980s. Since then, collecting rates have gradually eased off with collecting by the CGIAR Centres having leveled off since the early 2000s.[10]

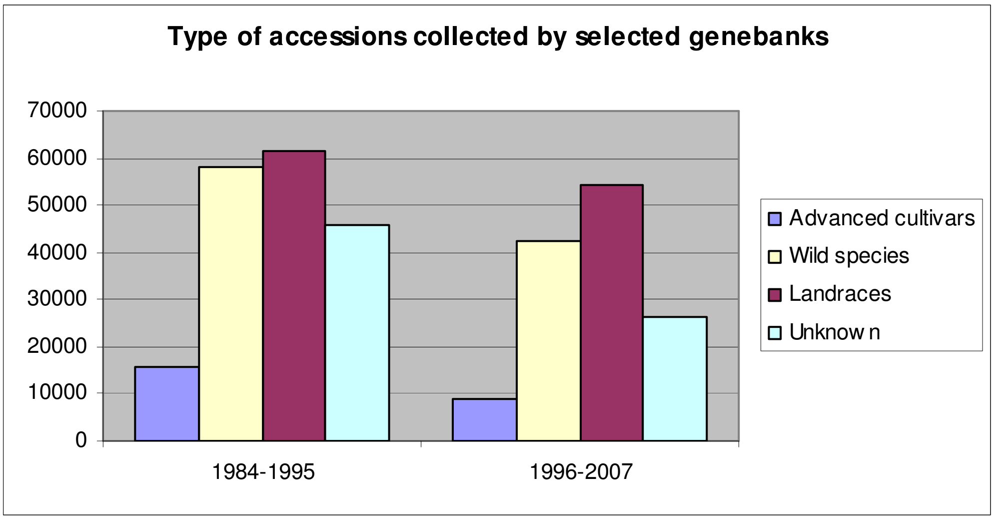
Figure 3.2 Number of accessions collected each year since 1920 and stored in selected genebanks, including those of the CGIAR[11]



Source: 31 genebanks of the NPGS of USDA (source GRIN 2008); 234 genebanks from Europe (source EURISCO 2008); 12 genebanks from SADC (source SDIS 2007); NGBK (Kenya) (source: dir. info. 2008); DENAREF (Ecuador) (source: dir. info. 2008); NBPGR (India) (source dir. info 2008); IRRI, ICARDA, ICRISAT and AVRDC (source: dir. info. 2008); CIP, CIMMYT, ICRAF, IITA, ILRI, WARDA (source SINGER 2008).

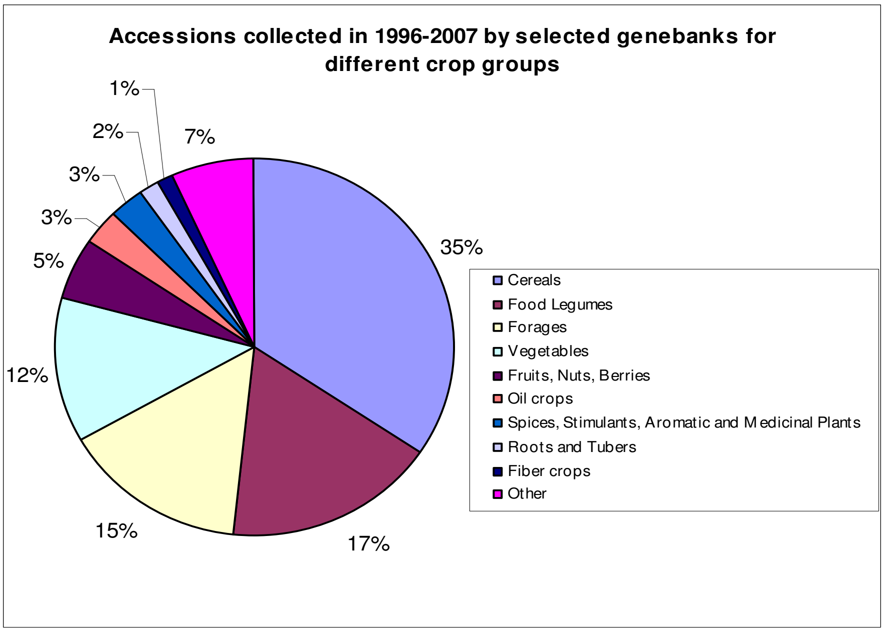
An indication of the type of accessions collected by selected genebanks over two time periods, 1984-95 and 1996-2007 are shown in Figure 3.3 below, and Figure 3.4 shows the types of crop collected over the latter period, 1996-2007.

Figure 3.3 Type of accessions collected by selected genebanks over two time periods



Source: 31 genebanks of the NPGS of USDA (source GRIN 2008); 234 genebanks from Europe (source EURISCO 2008); 12 genebanks from SADC (source SDIS 2007); NGBK (Kenya) (source: dir. info. 2008); DENAREF (Ecuador) (source: dir. info. 2008); NBPGR (India) (source dir. info 2008); IRRI, ICARDA, ICRISAT and AVRDC (source: dir. info. 2008); CIP, CIMMYT, ICRAF, IITA, ILRI, WARDA (source SINGER 2008).

Figure 3.4 Accessions collected by selected genebanks in 1996-2007 according to crop group



Source: 31 genebanks of the NPGS of USDA (source GRIN 2008); 234 genebanks from Europe (source EURISCO 2008); 12 genebanks from SADC (source SDIS 2007); NGBK (Kenya) (source: dir. info. 2008); DENAREF (Ecuador) (source: dir. info. 2008); NBPGR (India) (source dir. info 2008); IRRI, ICARDA, ICRISAT and AVRDC (source: dir. info. 2008); CIP, CIMMYT, ICRAF, IITA, ILRI, WARDA (source SINGER 2008).

3.3.1 Situation in the regions

Most collecting missions during the last ten years have taken place in country and they have mostly aimed either to fill gaps in collections or to recollect germplasm lost during *ex situ* conservation. With changing patterns of land use and increasing environmental degradation in many parts of the world, there has also been a perceived need to collect material for *ex* *situ* conservation that might otherwise have been conserved *in situ*. Concern about the effects of impending climate change have also steered some germplasm collecting in the direction of specific traits, such as drought and heat tolerance.[12]

Africa

Many African nations reported carrying out collecting missions over recent years, resulting in more than 35,000 new accessions. Since 1995 more than 4,000 accessions from some 650 genera have been collected and added to the collection in the National Genebank of Kenya. A wide range of species including cereals, oil plants, fruits and roots and tubers have been collected in Benin, and the country reports of Angola, Cameroon, Madagascar, Tanzania, Togo and Zambia all reported the collecting of germplasm over recent years. Five missions were organized in Ghana that yielded nearly 9,000 new accessions of legumes, maize, roots and tubers, fruits and nuts. The largest number of missions was carried out in Namibia; 73 between 1995 and 2008, to collect rice wild relatives and local vegetables and legumes.

Americas

Germplasm collection missions mounted in South America over the last decade included 13 by Argentina, yielding over 7,000 accessions of various crops including forages, ornamentals and forest species; 18 by Bolivia for crops of national interest including oxalis, quinoa, beans and maize; and 4 by Paraguay to collect maize, peppers and cotton. Chile carried out an unspecified number of missions that resulted in over 1,000 new accessions and Uruguay also reported collecting, mainly forages. In total about 10,000 accessions were collected in South America. In North America, USDA has collected samples of more than 4,240 species since 1996, from many different countries. In total more than 22,150 accessions were collected of which some 78% were wild materials. The genera yielding the largest number of accessions were: *Malus* (2795) *Pisum* (1,405), *Poa* (832), *Cicer* (578), *Medicago* (527), *Glycine* (434), *Vicia* (426) and *Phaseolus* (413). Canada has collected accessions of wild relatives and native crop-related biodiversity. In Central America and the Caribbean over the past decade Cuba has carried out 37 national collecting missions, Dominica 3, and St. Vincent and the Grenadines 2, mainly to collect fruits, vegetables and forages. The Dominican Republic, El Salvador and Trinidad and Tobago also reported having collected germplasm. In Guatemala, between 1998 and 2008, more than 2,300 accessions of a wide range of crops were collected including maize, beans, peppers and vegetables. Based on the country reports, about 2,600 accessions have been collected in Central America since 1996.

Asia and the Pacific

Many Asian country reports listed germplasm collecting missions undertaken since the publication of the first SoW report. Collectively they resulted in more than 129,000 new accessions. India undertook 78 national missions, collecting about 86,500 new accessions of 671 species. Bangladesh added about 13,000 accessions to its national genebank through national collecting missions whereas China only reported four missions. Between 1999 and 2007 Japan organized 40 foreign collecting missions (rice and legumes) and 64 national ones (fruits, legumes, forages and spices and industrials). Several other Asian countries reported that they had undertaken collecting but did not provide details. In the Pacific, the Cook Islands, Fiji, Palau and Samoa all indicated that regular germplasm collecting missions had been carried out for traditional crops including bananas, breadfruit, yams, taro and coconuts. Papua New Guinea has also undertaken several missions over recent years to collect staple crops.

Europe

Many European countries reported collecting germplasm over the past ten years, the majority of which was collected nationally or from nearby countries. In total more than 51,000 accessions were collected. Hungary reported having undertaken 50-100 national missions that gathered several thousand new accessions of cereals, pulses and vegetables;

Finland reported four missions in the Nordic region resulting in 136 new accessions of bird cherry and reed canary grass; Romania reported undertaking 36 national missions to collect cereals and legumes; and Slovakia carried out 33 missions nationally and in neighboring countries that resulted in over 6,500 landraces and wild crop relatives. Poland mounted 13 missions at home, in Eastern Europe and Central Asia that collected about 7,000 new accessions, and more than 2,500 accessions were collected by Portugal in 42 separate missions.

Near East
In-country collecting was reported by Egypt, Morocco and Jordan, the latter targeting mainly fruit trees and cereals. Missions were mounted in Oman, in collaboration with ICARDA and ICBA, to collect barley, forage and pasture species, and by national institutions in Iran, Pakistan, Syria, Tunisia and Tajikistan focusing mainly on cereals and legumes. Both Afghanistan and Iraq, having lost considerable amounts of conserved germplasm during recent conflicts, carried out national collecting missions; Iraq mainly for cereal wild relatives and Afghanistan primarily for food staples, almond, pistachio and pomegranate. Collecting missions took place in Kazakhstan in 2000, 2003 and 2004, targeting cereals, fodder crops and medicinal plants, and since 2000 the collecting of crop wild relatives has been conducted annually. Azerbaijan carried out 55 national missions between 1999 and 2006 that yielded more than 1,300 new accessions of a very large range of crops. According to the country reports, more than 14,000 accessions have been collected in the region over the past decade or so.

3.4 Types and status of collections

Both seed genebanks and field genebanks differ in their species coverage, the extent of the crop genepool that is covered, the types of accessions conserved (crop wild relatives, landraces, breeding lines, advanced cultivars, etc.), and the origin of the material. The large majority of genebanks, however, conserve germplasm of the major crop species, on which humans and livestock rely most for food and feed.

3.4.1 International and national genebanks

Eleven of the CGIAR Centres manage germplasm collections on behalf of the world community: Bioversity International, CIAT, CIMMYT, CIP, ICARDA, ICRAF, ICRISAT, IITA, ILRI, IRRI and WARDA. The CIMMYT, ICARDA, ICRISAT and IRRI collections all comprise more than 100,000 accessions each. Collectively, the Centres maintain a total of about 685,000 accessions from 3,145 species of 508 different genera (see also Table 1.1 in Chapter 1).

In addition many other international and regional institutions conserve important collections, for example:

- The Asian Vegetable Research and Development Center (AVRDC) maintains about 56,000 accessions of vegetable germplasm;
- The Nordic Genebank (NordGen) conserves about 28,000 accessions of a range of crops from 129 genera;
- The Center for Tropical Agricultural Research and Education (CATIE) has a total of more than 11,000 accessions of vegetables, fruits, coffee and cocoa;
- The SADC Plant Genetic Resources Centre (SPGRC) maintains more than 10,500 accessions of a range of crops important for African agriculture;

- The West Indies Central Sugarcane Breeding Station in Barbados conserves about 3,500 accessions;
- The International Cocoa Genebank, Trinidad (ICG,T) at the University of the West Indies conserves about 2,300 accessions; and
- The Centre for Pacific Crops and Trees (CePaCT) of the Secretariat of the Pacific Community holds collections of about 1,500 accessions from several crops, including taro, yam and sweet potato.

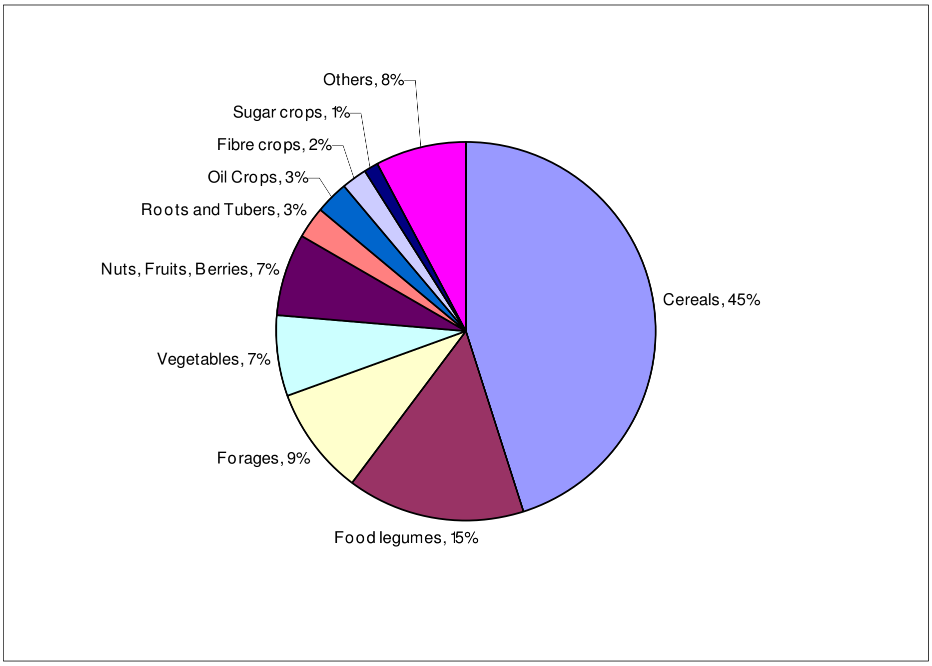
A highly significant development since the publication of the first SoW report has been the creation of the Svalbard Global Seed Vault (SGSV). While not a genebank in the strictest sense, SGSV provides secure facilities for the storage of back-up samples of accessions from genebanks around the world (see Section 3.5 below).

Around the globe, genebanks are maintained at the local and national level by governments, universities, NGOs and the private sector. They house a wide range of different types of collection - whether national collections maintained for the long-term, working collections maintained for the medium- or short-tem, collections of genetic stocks or others. The four largest national genebanks are those housed at the Institute of Crop Germplasm Resources (ICGR) in China, the National Center for Genetic Resources Preservation in the USA[13], the National Bureau of Plant Genetic Resources (NBPGR) in India and the N.I. Vavilov All-Russian Scientific Research Institute (VIR) (see Table 1.2, Chapter 1). National genebanks housing more than 100,000 accessions are also found in Brazil, Canada, Germany, Japan and South Korea. The National Plant Germplasm System of the United States Department of Agriculture (USDA) operates a unique system of germplasm conservation that networks 31 genebanks within the country and conserves more than 7% of the germplasm holdings representing more than 50% of the genera, conserved in genebanks worldwide. The Millennium Seed Bank is the world’s largest seed genebank devoted to the conservation of wild species. It is run by the Royal Botanic Gardens at Kew, which also has sizeable living collections as well as herbarium and carpological collections.

3.4.2 Crop species coverage

Information in the WIEWS database indicates that about 45% of all the accessions in the world's genebanks are cereals. The country reports confirm this. Food legumes are the next largest group, accounting for about 15% of all accessions, and vegetables, fruits and forage crops each account for 7-8% of the total number of accessions maintained *ex situ*. Roots and tubers, oil and fibre crops each account for 2-3% of the total (see Figure 3.5). These percentages are very similar to those presented in the first SoW report.

Figure 3.5 Contribution of major crop groups in total ex situ collections



Source: WIEWS 2009

Many countries reported increases in the number of accessions held in their genebanks since 1996 and additional information on this is available in the WIEWS database. Angola, for example, added more than 1,800 local landraces of more than 33 species to its national genebank. Most countries in South America reported increases in their germplasm holdings, many of which now house more than 50% more accessions than they did in 1996.[14] The only significant increase in holdings reported in Central America was in Mexico, where total holdings have increased by more than 160% since the first SoW report was published. In Asia, since 1996 the number of accessions stored at NBPGR in India grew by 130% and Bangladesh added more than 13,000 accessions to its national collection. During the same period, holdings in China's national genebank increased by nearly 33,000. Within the Pacific, only Australia's holdings appear to have increased - from 123,000 at the time the first SoW report was published, to 212,545 today. In Europe, Hungary added over 4,500 accessions in 1998 and between 130 and over 700 new accessions annually thereafter. Spain reported adding more than 24,000 new accessions to its national collection over the last ten years. Yemen doubled the number of accessions conserved in its field genebanks and added over 4,000 accessions, mainly of cereals and legumes, to its national collection.

Although the overall growth in the number of accessions conserved over the past decade are impressive, it should be noted, however, that some or even much of this might be due to the unplanned duplication of samples within and among collections as well as to improved surveying and reporting, rather than only to a real growth in total holdings.

Table 3.2 Holders of the six largest *ex situ* collections of major crops (to be inserted here)

Genus (crop)	Total World Accessions	Major holders Rank											
		1	%	2	%	3	%	4	%	5	%	6	%
Triticum (wheat)	863,472	CIMMYT	13	NSGC (USA029)	7	ICGR-CAAS (CHN001)	5	NBPGR (IND001)	4	ICARDA	4	(several)	4
Oryza (rice)	780,462	IRRI	14	NBPGR (IND001)	11	CNRRI (CHN121)	9	NIAR (JPN003)	6	RDAGB-GRD (KOR011)	3	DB NRRC (USA970)	3
Hordeum (barley)	472,429	PGRC (CAN004)	8	NSGC (USA029)	6	CENARGEN (BRA003)	6	ICARDA	6	NIAR (JPN003)	5	IPK (DEU146)	5
Zea (mays)	334,037	CIMMYT	8	BPGV-DRAEDM (PRT001)	7	NC7 (USA020)	6	ICGR-CAAS (CHN001)	6	INIFAP (MEX008)	4	VIR (RUS001)	3
Phaseolus (bean)	264,306	CIAT	14	W6 (USA022)	6	CNPAF (BRA008)	5	INIFAP (MEX008)	5	IPK (DEU146)	3	ICGR-CAAS (CHN001)	3
Sorghum (sorghum)	239,466	ICRISAT	16	S9 (USA016)	15	ICGR-CAAS (CHN001)	8	NBPGR (IND001)	7	IBC (ETH085)	4	CNPMS (BRA001)	3
Glycine (soybean)	229,979	ICGR-CAAS (CHN001)	14	SOY (USA033)	9	RDAGB-GRD (KOR011)	8	AVRDC	7	CNPSO (BRA014)	5	NIAR (JPN003)	5
Avena (oat)	148,611	PGRC (CAN004)	18	NSGC (USA029)	14	VIR (RUS001)	8	IPK (DEU146)	3	KARI-NGBK (KEN015)	3	TAMAWC (AUS003)	2
Arachis (groundnut)	121,009	ICRISAT	13	NBPGR (IND001)	11	S9 (USA016)	8	UNSE-INSIMA (ARG1342)	7	ICGR-CAAS (CHN001)	5	(several)	2
Gossypium (cotton)	105,281	UzRICBSP (UZB036)	11	COT (USA049)	9	CICR (IND512)	9	ICGR-CAAS (CHN001)	7	VIR (RUS001)	6	IRCT-CIRAD (FRA002)	4
Solanum (potato)	100,505	INRA-RENNES (FRA179)	11	VIR (RUS001)	9	CIP	7	IPK (DEU159)	6	NR6 (USA004)	6	NIAR (JPN003)	3
Cicer (chickpea)	98,574	ICRISAT	20	NBPGR (IND001)	15	ICARDA	13	ATFCC (AUS039)	9	W6 (USA022)	6	NPGBI-SPII (IRN029)	6
Pisum (pea)	96,555	ATFCC (AUS039)	7	VIR (RUS001)	7	ICARDA	6	IPK (DEU146)	6	W6 (USA022)	6	IGV (ITA004)	4
Hevea (rubber)	85,511	MRB (MYS111)	70	RRII (IND031)	6	IDEFOR-DPL (CIV061)	3	FPC (LBR004)	1	IAC (BRA006)	1	VNM009 (VNM009)	1
Lycopersicon (tomato)	84,758	AVRDC	9	NE9 (USA003)	7	IPB-UPLB (PHL130)	6	IPK (DEU146)	5	VIR (RUS001)	3	NIAR (JPN003)	3
Capsicum (capsicum)	78,248	AVRDC	10	S9 (USA016)	6	INIFAP (MEX008)	6	IHCF (BGR030)	5	NBPGR (IND001)	5	IAC (BRA006)	3
Malus (apple)	60,145	CAN079 (CAN079)	12	GEN (USA167)	12	VIR (RUS001)	6	NIAR (JPN003)	4	NFC (GBR030)	3	(several)	3
Trifolium (clover)	71,205	WADA (AUS137)	16	AGRESEARCH (NZL001)	9	ICARDA	6	W6 (USA022)	5	SIAEX (ESP010)	5	VIR (RUS001)	4
Prunus (prunus)	69,217	VIR (RUS001)	10	UNMIHT (USA276)	9	CRA-FRU (ITA378)	3	EFOPP (HUN021)	3	AARI (TUR001)	3	(several)	2
Vigna (cowpea)	64,884	IITA	24	S9 (USA016)	12	CENARGEN (BRA003)	8	LBN (IDN002)	6	NBPGR (IND001)	5	ICGR-CAAS (CHN001)	4
Pennisetum (pearl millet)	60,532	ICRISAT	36	CNPMS (BRA001)	12	NBPGR (IND064)	10	ORSTOM-MONTP (FRA202)	7	PGRC (CAN004)	6	SAARI (UGA001)	4
Lens (lentil)	58,617	ICARDA	19	NBPGR (IND001)	17	ATFCC (AUS039)	9	NPGBI-SPII (IRN029)	5	W6 (USA022)	5	VIR (RUS001)	4
Vicia (faba bean)	44,535	ICARDA	21	ICGR-CAAS (CHN001)	9	ATFCC (AUS039)	6	IPK (DEU146)	4	INRA-RENNES (FRA010)	4	UC-ICN (ECU003)	4
Aegilops (wheat)	41,720	ICCI-TELAVUN (ISR003)	22	ICARDA	9	NPGBI-SPII (IRN029)	6	NIAR (JPN003)	6	VIR (RUS001)	5	NSGC (USA029)	5
Saccharum (sugarcane)	41,128	CTC (BRA189)	12	INICA (CUB041)	9	WICSBS	8	NIAR (JPN003)	7	MIA (USA047)	6	GUY016 (GUY016)	5
X Triticosecale (wheat)	40,230	CIMMYT	43	IHAR (POL003)	5	VIR (RUS001)	5	NSGC (USA029)	5	CAN091 (CAN091)	5	IR (UKR001)	4
Cucurbita (cucurbita)	39,793	VIR (RUS001)	15	CATIE	7	CENARGEN (BRA003)	5	ICGR-CAAS (CHN001)	4	INIFAP (MEX008)	4	NIAR (JPN003)	3
Helianthus (sunflower)	39,540	SRB002	13	NC7 (USA020)	9	ICGR-CAAS (CHN001)	7	INRA-CLERMON (FRA040)	6	CNPSO (BRA014)	6	VIR (RUS001)	4
	34,602	IHAR (POL003)	13	NIAR (JPN003)	12	W6 (USA022)	7	IPK (DEU271)	6	WPBS-GRU-IGER (GBR016)	4	LRS (CAN041)	3

Genus (crop)	Total World Accessions	Major holders Rank											
		1	%	2	%	3	%	4	%	5	%	6	%
Festuca (fescue)													
Ipomoea (sweet potato)	34,593	CIP	19	NIAR (JPN003)	17	S9 (USA016)	3	CNPH (BRA012)	3	BAAFS (CHN146)	2	(several)	2
Manihot (cassava)	32,317	CIAT	17	CNPMF (BRA004)	9	IITA	9	ICAR (IND007)	4	NRCRI (NGA002)	4	SAARI (UGA001)	4
Dactylis (grasses)	32,083	BYDG (POL022)	19	NGRI (JPN019)	8	IPK (DEU271)	6	W6 (USA022)	5	WPBS-GRU-IGER (GBR016)	4	CSICMBG (ESP009)	2
Coffea (coffee)	29,806	IRCC/CIRAD (CIV011)	22	IAC (BRA006)	14	CIRAD (FRA014)	13	CATIE	6	ECICC (CUB035)	5	JARC (ETH075)	4
Mangifera (mango)	25,561	AUS088 (AUS088)	73	CISH (IND045)	3	HRI-DA/THA (THA056)	1	MIA (USA047)	1	MARIF (IDN017)	1	NUC (SLE015)	1
Beta (sugarbeet)	22,565	W6 (USA022)	11	IPK (DEU146)	10	SRB002	9	INRA-DIJON (FRA043)	7	ICGR-CAAS (CHN001)	6	VIR (RUS001)	6
Elaeis (oil-palm)	21,101	INERA (COD003)	84	MPOB (MYS104)	7	CPAA (BRA027)	3	ICA/REGION 5 (COL096)	1	BPP (IDN029)	1	NUC (SLE015)	1
Fragaria (strawberry)	14,146	CAN079 (CAN079)	13	COR (USA026)	13	VIR (RUS001)	7	NIAR (JPN003)	6	JKI (DEU451)	4	CIFACHU (ESP138)	4
Panicum (millet)	17,629	NIAR (JPN003)	33	KARI-NGBK (KEN015)	13	S9 (USA016)	4	CIV010 (CIV010)	3	CIAT	3	ORSTOM-MONTP (FRA202)	3
Dioscorea (yam)	16,320	IITA (NGA039)	20	CIV006 (CIV006)	9	UAC (BEN030)	7	PGRRI (GHA087)	6	SLB001 (SLB001)	3	LKA002 (LKA002)	3
Chenopodium (chenopodium)	16,245	BNGGA-PROINPA (BOL138)	27	INIA-EEA.ILL (PER014)	9	IPK (DEU146)	7	DENAREF (ECU023)	4	UBA-FA (ARG1191)	3	U.NACIONAL (COL006)	2
Musa (banana)	13,410	INIBAP	9	CIRAD (FRA014)	4	DTRUFC (HND003)	4	DLP Laloki (PNG004)	4	QDPI (AUS035)	3	CNPMF (BRA004)	3
Theobroma (cocoa)	12,372	CRU (TTO005)	19	CRIG (GHA005)	8	CEPEC (BRA074)	6	CORPOICA (COL029)	6	CATIE	6	(several)	6
Eragrostis (millet)	8,817	IBC (ETH085)	54	W6 (USA022)	15	KARI-NGBK (KEN015)	12	NIAR (JPN003)	4	NBPGR (IND001)	3	CIFAP-CAL (MEX035)	3
Colocasia (taro)	6,164	MARDI (MYS003)	10	NBPGR (IND024)	8	HRI-DA/THA (THA056)	7	WLMP (PNG006)	7	PRC (VNM049)	6	LBN (IDN002)	6
Psophocarpus (bean)	4,231	FRUITUR (ITA047)	34	COR (USA026)	19	AARI (TUR001)	9	KPS (UKR046)	4	AZE009 (AZE009)	4	IRTAMB (ESP014)	3
Corylus (nut)	2,959	DOA (PNG005)	11	MYS009 (MYS009)	10	TROPIC (CZE075)	10	IDI (LKA005)	9	LBN (IDN002)	9	(several)	6
Olea (olive)	2,638	UCR-BIO (CRI016)	31	CATIE	24	IAC (BRA006)	13	CORPOICA (COL029)	10	EENP (ECU022)	6	INRENARE (PAN002)	3

Major crops
Holders of the six largest *ex situ* collections of selected major crops are listed in Table 3.2. In terms of the total number of *ex situ* accessions, wheat, rice, barley and maize are the most important cereals and account for 76% of the total cereal and pseudo-cereal holdings. Other important cereals are sorghum (more than 230,000 accessions) and pearl millet (more than 61,000 accessions). In some tropical countries, roots and tubers, including cassava, potato, yam, sweet potato and aroids, are more important staple food crops than cereals, but being more difficult to conserve, collection sizes tend to be smaller. CIP holds the world's largest sweet potato collection (more than 6,000 accessions) and the third largest potato collection (representing about 8% of total world holdings of about 100,000 accessions) after those of INRA-Rennes (France) and VIR (Russian Federation). Other important collections of *Solanum* are found at IPK (Germany) and USDA (Sturgeon Bay, USA). The largest cassava collection (more than 5,000 accessions) is held by CIAT in Colombia, followed by the collections of Embrapa (Brazil) and IITA (Nigeria).

The genebanks of the CGIAR generally represent the major repositories for germplasm of their mandate crops. For example: the world's major wheat (9% of the total) and maize (8% of the total) collections are held at CIMMYT, that of rice (14% of total) is at IRRI. ICRISAT maintains the world's largest collections of sorghum (15%), pearl millet (36%), chickpea (18%) and groundnut (13%). ICARDA houses the world's largest collections of lentil (19%), faba bean (21%) and vetches (15%). CIAT is responsible for the world's largest collections of beans (14%) and cassava (17%).

China holds the largest collection of soybean germplasm (14% of the world's accessions). Among the fruits, *Prunus* species are represented by more than 69,000 accessions, including breeding and research materials, with VIR in Russian Federation holding 10% and CRA-FRU in Italy 3% of the total. *Vitis* species are the second most important fruits according to numbers of accessions the largest shares being held by INRA/ENSA-M in France (8%) and JKI in Germany (6%). USDA has a substantial collection of fruit, nut and horticultural crop. USDA has a substantial collection of fruit, nut and horticultural crop germplasm in Corvallis, Oregon State University, and in Geneva, Cornell University. After Bioversity's International *Musa* collection maintained at the International Transit Centre in Leuven, the most important banana germplasm holdings are at CIRAD in Guadeloupe, DLP Laloki in Papua New Guinea and FHIA in Honduras. Among the vegetables, most accessions are for tomato followed by peppers (*Capsicum* spp.). The largest collections are at AVRDC, which accounts for about 10% of the total for both crops. Other important collections of tomato are held at USDA in Geneva and IPK in Germany, and of *Capsicum* at USDA in Griffin, INIFAP in Mexico and IHCF in Bulgaria.

Australia is the predominant holder of forage legume germplasm, with 31% of the world holdings of *Medicago* at AMGRC and 16% of the world's clover holdings at WADA. The most important temperate forage grasses include *Festuca*, *Dactylis* and *Lolium* (approximately 92,000 accessions among them). Some of the largest collections of these are held in Poland and Germany. Among the tropical forage grasses, KARI's National Genebank of Kenya holds the largest collection of *Cenchrus*, while CIAT and ILRI together hold the largest collection of *Brachiaria*. Among oilseed crops, sesame accounts for more than 49,000 accessions globally and sunflower almost 30,000. The largest single collections of these are held by India (17%) and Serbia (17%), respectively.

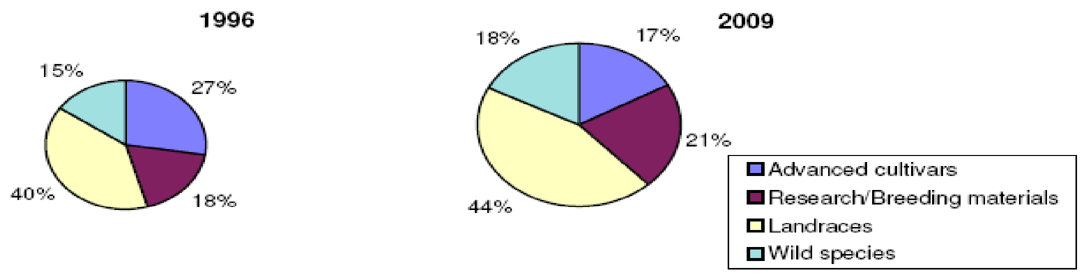
Cotton is the most important fibre crop with more than 104,000 accessions worldwide, 11% of which are held in Uzbekistan at UzRICBSP, and of the more than 85,000 accessions of rubber, 70% are conserved in Malaysia at MRB. Among the major beverages, the largest collection of coffee is held in Côte d'Ivoire (22%) and of cacao by ICG at the University of the West Indies in Trinidad and Tobago (19%).

Minor crops and wild relatives
According to the country reports there has been a growing interest since 1995 in collecting and conserving minor, neglected and underused crops. In the case of yam, for example, the number of conserved accessions has increased from 11,500 in 1995 to 16,300 in 2008, and in bambara groundnut from 3,500 in 1995 to 6,100 in 2008. This increasing interest in minor crops reflects, in part, the growing realization that many of them are under threat due to replacement by major crops or the disappearance of the agricultural environments in which they are grown. Similarly, concerns exist for crop wild relatives whose natural habitats are under threat, compounded by concerns over climate change and the realization that many crop wild relatives could possess traits such as biotic and abiotic stress resistance or tolerance that could be useful in adapting crops to changing conditions.

3.4.3 Types of material stored

The nature of the accessions (for example whether they comprise advanced cultivars, breeding lines, landraces, wild relatives, etc.) is known for about half of the material conserved *ex situ*. Of these, about 17% are advanced cultivars, 22% breeding lines, 44% landraces and 17% wild or weedy species[15]. As Figure 3.6 shows, the number of accessions conserved worldwide of landraces, breeding material and wild species has increased since the first SoW report was published, possibly reflecting a growing interest in securing such material before it is lost, as well as for use in genetic enhancement programmes.

Figure 3.6 Types of accessions in *ex situ* germplasm collections in 1996 and 2008 (the size difference in the charts represents the growth in total numbers of accessions held *ex situ* between 1996 and 2008)



Source: WIEWS 1996 and 2009

Table 3.3 below provides a breakdown of type of accession by groups of crops. Forages and industrial crops show a relatively high percentage of accessions that are wild relatives. The reverse is true for sugar crops, the majority of which are represented by advanced cultivars.

Table 3.3 Global germplasm holdings in terms of type of accession (mean %) for groups of crops included in Annex 2

Commodity group	No. of accessions	% Wild species	% Landraces	% Breeding materials	% Advanced cultivars	% Others
Cereals	3,203,570	4	28	15	8	45
Food legumes	1,069,490	4	32	6	9	49
Roots and tubers	202,909	10	30	13	11	36
Vegetables	508,205	5	21	7	14	53
Nuts, fruits, berries	451,609	6	13	18	20	43
Oil crops	184,379	6	21	15	11	47
Forages	653,499	33	13	3	4	47
Sugar crops	63,693	7	7	11	25	50
Fibre crops	169,477	4	18	10	10	58
Medicinal, aromatic, spice and stimulant crops	159,797	13	23	7	9	48
Industrial, ornamental plants	164,027	50	1	2	4	44
Other	251,595	27	4	2	2	65
Total/overall mean	**7,082,250**	**9**	**24**	**11**	**9**	**47**

Source: WIEWS 2009

3.4.4 Source of material in genebanks

About 56% of all accessions held in genebanks globally for which the country of origin is known, are indigenous, i.e. they originated in the country where the collection is maintained. Table 3.4 shows the total number of accessions and the proportion of indigenous germplasm on a regional and sub-regional basis.

Table 3.4 Number and percentage of accessions of local origin in *ex situ* genebanks, excluding collections held in international and regional genebanks

Region	Sub-region	Number of Indigenous accessions	Total number of accessions[16]	% of indigenous accessions
Africa	West Africa	29,743	37,604	79
Africa	Central Africa	934	20,277	5
Africa	Eastern Africa	100,125	119,676	84
Africa	Southern Africa	40,853	41,171	99
Africa	Indian Ocean Islands	131	273	48
America	South America	145,242	180,572	80
America	Central America and Mexico	41,370	51,513	80
America	Caribbean	13,746	23,671	58
America	North America	95,240	422,477	23
Asia and the Pacific	East Asia	179,055	255,673	70
Asia and the Pacific	South Asia	420,019	443,573	95
Asia and the Pacific	Southeast Asia	77,363	153,513	50
Asia and the Pacific	Pacific	43,056	189,408	23
Europe	Europe	343,044	927,815	37
Near East	South/East Mediterranean	66,363	73,428	90
Near East	West Asia	58,735	59,255	99
Near East	Central Asia	20,375	25,283	81
World		**1,671,760**	**3,008,788**	**56**

Source: WIEWS 2009

The percentage is greatest for West Asia, Southern Africa and South Asia, and is lowest for Central Africa, North America and the Pacific. In general, the distribution of accessions held in genebanks between native and exotic germplasm appeared little changed from that reported in the first SoW report and overall large national genebanks tend to maintain a greater proportion of non-indigenous materials than smaller ones.

For Africa, indigenous germplasm predominates in the collections of the SADC countries, Cameroon and Kenya. Country reports from the Asia and the Pacific region indicate that accessions are predominantly indigenous in Papua New Guinea, Samoa, Sri Lanka and Vietnam while in the Cook Islands, Fiji and Palau they are exclusively so. China and Japan reported possessing about twice as many foreign as native accessions.

In the Americas, the majority of accessions in the Caribbean, and in Central and South American national genebanks were of native origin with the exception of Brazil and Uruguay that reported more than six times and more than three times respectively, the number of foreign accessions compared to native ones. According to the USDA GRIN database, native materials comprise about 16% of the total germplasm conserved in the USA's National Plant Germplasm System.

A wide range in origins of germplasm is reported in European genebanks. All of Cyprus's and Turkey's holdings are indigenous, as are 85% of those stored in Portugal. About 80% of germplasm conserved at NORDGEN originated in the five countries served by the genebank. However, the percentage of indigenous accessions in the national genebanks of Germany, the Netherlands, Czech Republic, Romania, and Russian Federation varies between 14-17%. Greece, Hungary, Italy and Spain also conserve more foreign germplasm than native, and in France exotic material accounts for more than 90% of the total.

In the Near East and North Africa region, the majority of accessions in the national genebanks are of native origin; exclusively so for Jordan, Kyrgyzstan and Lebanon and predominantly so for Pakistan, Tajikistan and Yemen.

3.4.5 Gaps in collection coverage

The extent of coverage of the total diversity of different crops in *ex situ* collections is difficult if not impossible to estimate with any real precision but clearly it varies considerably according to crop and according to the perceptions of different stakeholder groups. Over recent years, the Global Crop Diversity Trust has supported the development of a number of crop and regional conservation strategies[17]. These have brought together information from different countries and organizations and, *inter alia,* have attempted to identify major gaps in *ex situ* collections as estimated by different stakeholders. Thus for wheat, according to the opinion of collection managers, the major gaps in collections are of landraces and cultivars. Key users of wheat genetic resources, however, indicated the need for more mapping populations, mutants, genetic stocks and a wider range of wild relatives. For maize the situation is slightly different as there are relatively few areas where no comprehensive collection has been made. Major gaps identified in existing *ex situ* maize collections thus include hybrids and tropical inbred lines, in addition to gaps resulting from the loss of accessions from collections; for example, the entire collection of Dominica was lost as was much of the maize collected by IBPGR in the 1970s. For barley there are gaps in collections of wild relatives, and many species and populations are endangered as a result of the loss of their natural habitats.

For potatoes, most useful genetic material has already been collected and there are currently few significant gaps. However, several Latin American collections are threatened by lack of funding and, if lost, would result in important gaps in the overall coverage of the genepool. The situation for sweet potato is somewhat different, with important geographic as well as trait gaps having been identified. Among the best estimates of genepool coverage are those for banana and plantain. About 300-400 key cultivars are known to be missing from the International Transit Collection including 20 plantains from Africa, 50 *Callimusa* from Borneo, 20-30 *M. balbisiana* and 20 other types from China and India, 10 accessions from Myanmar, 40 wild types from Indonesia and Thailand, and up to 100 wild types from the Pacific.

The situation for legumes is different again. For lentil, landraces from China and Morocco and wild species, particularly from southeast Turkey, are not well represented in collections. There are gaps in chickpea collections from Central Asia and Ethiopia and there are relatively few accessions of wild relatives, particularly from the secondary genepool. For faba bean various geographic gaps have been identified including local varieties and landraces from North Africa, the Egyptian oases, South America and China. The small-seeded subspecies, *paucijuga,* is also under-represented in collections and there are trait gaps, especially for heat tolerance. An important consideration for many legume collections is the need to also collect and maintain samples of *Rhizobium*. This is especially the case for wild legume species, but such *Rhizobium* collections are rare.

While there are still sizeable gaps in the *ex situ* collections of many major crops, these tend to be small in comparison with those in the collections of the more minor crops. Indeed, many useful plant species only occur in the wild or as landraces on farmers' fields. In many cases such species are threatened by the vagaries of climate and changes in land use.

A problem common to many crops is the difficulty in conserving their wild relatives, especially perennials. As a result they are often missing from collections and are generally best conserved *in situ* as they can be difficult to collect and maintain *ex situ,* or can become serious weeds.

While there is a better understanding of the extent and nature of gaps in *ex situ* collections than was the case at the time of the first SoW report, the picture is still far from complete. The use of molecular data to better understand the nature, extent and distribution of genetic diversity, more detailed field surveys and better geo-referencing of accessions would all be helpful in efforts to more accurately identify gaps and duplication within and among individual collections and in genepools as a whole.

3.4.6 Conservation of DNA samples and nucleotide sequence information

In addition to storing seeds and whole plants, plant genetic resources can also be stored in the form of isolated DNA maintained at low temperature or electronically as sequence data on computers – *in silico*. The latter is becoming increasingly possible as data storage costs fall and the power of analytical tools increases. While current technology does not permit the regeneration of the original plant from isolated DNA or electronic information sources, these can be used in many ways, e.g. in genetic diversity and taxonomic studies. In 2004, Bioversity International conducted a survey of international and national conservation programmes, botanic gardens, universities and private companies involved in PGRFA conservation in 134 countries. The results provide useful baseline information on the use of plant DNA storage. Only 21% of the 243 respondents stored plant DNA, with about as many in developing as in developed countries. Lack of funds, equipment, personnel and training were cited as the main reasons by the remainder for not employing DNA storage. Nearly half of the institutions that conserve DNA supply it to others for research, despite what many considered to be a somewhat unclear legal situation. Bioversity International published the results of the survey in 2006[18] in a publication that also discusses options and strategies for integrating DNA and sequence information with other conservation approaches. There is still considerable debate within the PGRFA community about the current and potential future role of DNA and sequence information storage for conservation purposes.

3.5 Storage facilities

Since the publication of the first SoW report there has been an increase in storage capacity as new genebanks have been established and existing ones expanded. However, this says little about storage conditions and whether there has been a general improvement. There remains an enormous range in types and conditions of storage facilities worldwide. The problems associated with storage facilities in the developed world are magnified in the developing world, where utilities are less reliable and funding more constrained.

Technical requirements for conserving seeds have been widely published[19,20] and broad recommendations can be generally made. The same is not true for conserving plants in field genebanks, *in vitro* storage or cryopreservation, where requirements can be highly crop specific and techniques demanding of management and facilities. While some countries in the developed and developing world are able to meet such demands, many are not, and consequently some collections are degenerating.

One of the major developments that has occurred since the publication of the first SoW report is the establishment of the SGSV, the ultimate safety net for *ex situ* seed collections of the world's most important crops. This is the world's first and only truly global germplasm conservation facility. Being located in the permafrost, 130 meters into a mountainside on an island just 800 km from the North Pole, SGSV provides unprecedented levels of physical security. The Government of Norway built the facility as a service to humanity and maintains and operates it with support from the Global Crop Diversity Trust and the Nordic Genebank. The seed vault opened in early 2008 and to date houses more than 410,000 accessions, all of which are safety duplicate copies of material already held in *ex situ* collections elsewhere. All materials in SGSV remain under the ownership and control of the depositor. It is important to note, however, that the SGSV, as a global last-resort seed repository, does not provide safety duplication in the common sense, since viability of the seed is not periodically monitored nor the seed regenerated. Depositors are expected to provide fresh samples of seed at a time when it is estimated that viability has decreased. Details of the collections deposited in SGSV are provided in Table 3.5.

Table 3.5 Germplasm holdings at SGSV as of 18 June 2009

Depositor	Number of			
	Genera	**Species**	**Accessions**	**Countries of origin**
Centre for Genetic Resources (the Netherlands)	31	224	18,212	143
Department of Agriculture, Food and Rural Development (Ireland)	3	4	100	4
Institute of Plant Production n.a. V.Y. Yurjev of UAAS (Ukraine)	5	7	885	31
Leibniz Institute of Plant Genetics and Crop Plant Research (Germany)	408	1,272	17,671	110
N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry (Russian Fed.)	12	40	945	68
National Agrobiodiversity Center (Korea)	26	32	13,185	1
National Genebank of Kenya (Kenya)	3	4	558	1
National Plant Genetic Resources Laboratory (the Philippines)	3	4	500	16
National Plant Germplasm System (USA)	223	827	30,868	150
Nordic Genetic Resource Center	84	226	12,698	73
Oak Park Research Centre (Ireland)	6	7	577	1
Plant Gene Resources of Canada, Saskatoon Research Centre (Canada)	50	154	9,233	83
Plant Genetic Resources Institute, National Agricultural Research Centre (Pakistan)	5	8	480	1
Seed Savers Exchange (USA)	19	39	1421	66
Station Fédérale de Recherches en Production Végétale de Changins (Switzerland)	3	3	3,845	21
Taiwan Agricultural Research Institute	1	1	4,018	1
AVRDC	12	55	7,350	89
CIAT	88	502	34,111	125
CIMMYT	4	6	80,492	57
CIP	2	173	5,847	23
ICARDA	29	249	62,834	117
ICRAF	63	120	508	27
ICRISAT	7	7	20,003	84
IITA	3	30	6,513	85
ILRI	112	506	4,008	91
IRRI	6	45	70,180	121
WARDA	1	4	5,404	64
Total (*)	**664**	**3,286**	**412,446**	**204**

(*) distinct for genera, species and countries of origin; undetermined genera and species are not counted. (Elaborated from http://www.nordgen.org/sgsv)

The following sections describe the status of facilities for conserving PGRFA in various regions as well as in the IARCs.

Africa

Based on the country reports, data on storage facilities in Africa are less complete than for other regions. Most countries reported having seed and field genebanks, but only Benin, Cameroon, Congo Brazzaville, Ghana, Kenya, Mali, Nigeria and Uganda reported having *in vitro* storage facilities. No country specified having an ability to conserve germplasm cryogenically. Seed genebanks are generally much more important and widespread in the continent than field genebanks. Ethiopia, for example, reported having 60,000 accessions in its national seed genebank, and 9,000 in its field genebank. Burkina Faso, Niger and Zambia all reported having many more accessions in their seed genebanks than in their field genebanks. Although most countries reported having long-, medium- and/or short-term storage facilities, there were many problems in their use, including reliability of electricity supplies, pests and disease problems, and lack of staff, equipment, or funds. Guinea reported loss of its entire *ex situ* collection as a result of lack of electric supply.

Asia and the Pacific
Virtually all Asian countries that submitted country reports indicated that they maintained both seed genebanks and field genebanks, but less than half stored germplasm *in vitro*, and only India, Indonesia, Japan, Nepal, Pakistan and Philippines use cryopreservation. China reported having 53 separate storage facilities, India 74 and Philippines 45, and several other Asian countries reported having up to ten. Long-, medium- and short-term facilities are available in most countries, but the relative numbers of each differed markedly among countries. While Japan and Pakistan reported meeting international standards for germplasm storage, according to the country reports many other countries were unable to meet such standards and there was room for improvement. The reasons stated for failure to meet international standards included lack of funds, insufficient and inadequately trained staff, lack of space, poor equipment and unreliable electricity supplies. Field genebanks predominate in the Pacific Islands countries, reflecting the regional importance of crops such as taro, coconut and banana that cannot be stored as seed. Fiji and Papua New Guinea were the only countries in the sub-region to report having *in vitro* storage. No information was supplied on the existence of long-, medium- or short-term seed storage facilities, although numerous problems were reported centering on the vulnerability of germplasm stored under field conditions.

Americas
Of the nine South American countries that submitted country reports, all maintained both seed and field genebanks and stored germplasm *in vitro*. Only Ecuador reported using cryopreservation, although Venezuela was preparing for it. Long-, medium- and short-term storage facilities were available in all countries. Brazil reported having 383 separate conservation facilities, Argentina 33 and Venezuela 26. Most other countries reported fewer than ten. Uruguay and Venezuela reported to have built new long-term facilities in the last ten years. Several countries met internationally agreed standards for genebank operations, but there were widespread problems of funding and staffing.

The large majority of countries in Central America and the Caribbean maintain long-, medium-, and short-tem seed stores, field genebanks and *in vitro* genebanks. In the sub-region, only Cuba reported activities on germplasm cryopreservation. As elsewhere, fewer accessions tend to be stored in field than seed genebanks: Cuba, for example reported having 4,000 accessions in the field compared with more than 12,000 seed accessions, and Mexico has approximately 61,000 field accessions and 107,000 seed accessions, although only half of these are in cold storage. However, roughly equal proportions of field and seed accessions are maintained in Costa Rica and El Salvador, while Dominican Republic conserves about four times more material in the field than in its seed genebank. Most countries reported having ten or fewer genebanks, while Mexico reported having about 150 genebanks, 22 of these having cold storage facilities but only three meeting international standards for long term conservation. As elsewhere in the developing world, many countries reported difficulties in maintaining international genebank standards and for the same reasons, although Cuba and Dominica also reported problems created by extreme weather events.

Europe
According to country reports, most European states have long-, medium- and short-term seed storage facilities as well as field genebanks. Belgium, Germany, Poland and Russian Federation maintain cryopreservation facilities and virtually all countries conserve some

germplasm *in vitro*. Hungary and Italy both reported having more than 60 separate storage facilities, but most countries have fewer than 20. However, the relative importance of the different types of storage varies considerably. Italy, for example conserves more germplasm in the field than in seed genebanks and Germany reported having more than 180,000 accessions in seed genebanks, about 25,000 in the field and 6,000 *in vitro*. Belgium, too reported substantial numbers of *in vitro* accessions (more than 1,500), largely reflecting the international collection of banana germplasm maintained in Leuven. In all cases international standards were met and of the few problems encountered, Albania reported a limitation of financial resources and skilled staff and Macedonia was hampered by the lack of a national strategy.

Near East
In 2004 the National Genebank of Egypt became operational with a storage capacity of 200,000 accessions (15% of which was used by the end of 2006) as well as facilities for *in vitro* conservation and cryopreservation. New long-term storage facilities have also been established in Morocco (2002) and Tunisia (2007). Tajikistan stated its reliance on donor funds to maintain storage facilities in good order and Uzbekistan indicated that it is modernizing its facilities. Most of the remaining countries are conserving their genetic resources under ambient or medium-term conservation conditions (5-10℃ with no relative humidity control). While several countries in this region do not have a genebank, some of them including Kuwait, Saudi Arabia and the United Arab Emirates have made plans for the establishment of long-term storage facilities to serve national and regional needs. A number of countries reported problems relating to funding, staffing and reliability of utilities.

IARC Genebanks
Since the publication of the first SoW there has been considerable upgrading of storage facilities among the IARCs. In 1996 the Japanese government funded a new genebank at CIMMYT. More recently, the World Bank supported two Global Public Goods projects to upgrade to standards all CGIAR genebanks. Through these projects, CIAT received a grant for converting cold rooms to a low temperature seed vault; ILRI has relatively recently installed new humidifiers and a new irrigation system for the field genebank, and in 2007 IRRI built a new long-term seed store and enlarged its screenhouse complex. The Global Public Goods projects funded renovation of IITA's facilities, where there are now improved cold storage chambers, drying rooms, *in vitro* laboratories and a store for yams. WARDA built a new cold room, screenhouses, a drying room and laboratories in Cotonou, Benin.

3.6 Security of stored material

Many of the world's collections of plant genetic resources are maintained under sub-optimal conditions that impact negatively on the viability of the collections. Two main areas of concern are the extent of safety duplication and backlogs with respect to regeneration. Both were already identified as significant issues in the first SoW report.

Although a substantial number of the world's accessions are duplicated, much of the duplication is inadvertent and it is often not possible with current data and information to identify the same accession in different collections. In this respect there has been little change since the publication of the first SoW report. Analyses based on country of origin suggest that only about 25-30% of the total number of accessions is distinct, in line with the first SoW report, but there are large differences according to species. A preliminary estimate of the duplication based on WIEWS data for selected crops indicates that for barley about 110,000 distinct accessions are stored worldwide compared with a total of 470 thousand accessions. This figure is in line with a separate study undertaken by the Global Crop Diversity Trust in the process of developing the Barley Crop Strategy[21]. Considerable safety duplication exists among the four largest barley collections; those of PGRC, USDA, EMBRAPA and ICARDA. There is a large overlap between the Canadian and USDA collections following safety duplication of the USDA collection of oats and barley in Canada in 1989, and the Brazilian collection is mostly integrated into that of USDA. The ICARDA collection is to be duplicated in the SGSV as a second level of safety, as are many other CGIAR collections, but it is already 33% duplicated at CIMMYT and 65% duplicated elsewhere. Many other barley collections are partly or wholly safety duplicated, but those of Bulgaria, Ecuador, France, Hungary and Italy, for example, are not. The duplication of accessions among collections, whether planned or unplanned, may result in large numbers of common accessions among different genebanks which, in turn, may be duplicated again as part of the planned safety duplication of entire collections. Whether duplication tends to occur primarily through a small number of samples being duplicated many times, or through a larger number of samples being duplicated only a few times, has yet to be determined for any crop.

Many wheat and maize germplasm collections are partially or wholly safety duplicated. According to a preliminary analysis, the lowest level of duplication is associated with vegetatively propagated and recalcitrant seeded plants, including cassava, yam and taro, cashew and rubber. Inadequate duplication also occurs for *Chenopodium*, *Eragrostis*, *Psophocarpus* and bambara groundnut, all of which are of high importance in local areas. Crop wild relatives, neglected and underused crops and newly domesticated crops also appear more vulnerable in terms of lack of safety duplication.

Banana germplasm is largely safety duplicated *in vitro*, but the situation for potato remains uncertain. For other crops, including lentil and chickpea, the degree of safety duplication is not well documented.

The Commission on Genetic Resources invited countries to inform it if there are important risks to *ex situ* genetic resources in their national collections, as part of an international Early Warning System. The Russian Federation alerted the Commission about the difficulties of the Vavilov Institute in the late 1990s.

Since the publication of the first SoW report, a major step forward in ensuring the safety of collections has been the establishment of the Global Crop Diversity Trust,[22] described elsewhere in this report (see Chapter 6.7). The Trust funds operations at the SGSV, and supports long-term storage in a small but growing number of genebanks.

The following sections summarize the germplasm security status of collections in the different regions.

Africa

Burkina Faso, Cameroon, Ethiopia, Mali and Niger reported the safety duplication of some of their germplasm in genebanks of the CGIAR. Namibia and Ghana both indicated that the majority of their germplasm was duplicated within the country. The regional SADC genebank provides safety duplication for all member country collections under long-term storage conditions. Uganda had not yet embarked on a programme of safety duplication, but Kenya reported having deposited safety duplicates of some of its germplasm in the Millennium Seed Bank, Kew.

Americas

In South America, Argentina reported safety duplicating its germplasm at CIP, CIMMYT, CIAT, IITA and USDA NCGRP. Chile reported similarly, but other countries provided no information. Very little information was provided in most of the country reports from Central America and the Caribbean, but Cuba and Mexico have undertaken a small amount of safety duplication.

Asia and the Pacific
As with Africa and the Americas, most of the Asia and the Pacific country reports provided little information on duplication, but major germplasm holding nations, including China and India, reported safety duplicating all accessions in country. Rice growing nations such as Indonesia, Lao PDR and Malaysia, all reported that IRRI maintains safety duplicates of their collections. Other IARC centers hold safety duplicates of crops from other countries. For example, Indonesia has deposited safety duplicates of banana germplasm at the International Transit Centre in Leuven, Belgium. The Centre for Pacific Crops and Trees (CePaCT) maintains safety duplicates of the national vegetatively propagated crop collections from the Pacific islands.

Europe
Most European countries indicated that their germplasm collections were safety duplicated to some extent, usually within their own national systems. All the Nordic countries, Denmark, Finland, Iceland, Norway and Sweden, reported having deposited safety duplicates of accessions in the SGSV. Other countries, including Romania, reported not having safety duplicated their collections and Russian Federation offered to make available facilities for the safety duplication to other countries.

Near East
Kazakhstan reported storing safety duplicates at VIR and IRRI, and other countries in the region, including Iran, Turkey and Uzbekistan, reported having safety duplicated at least some germplasm in country. Most of the cereal, legume and range species collected from the region are duplicated at ICARDA. Pakistan reported having safety duplicates of crop germplasm collections at ICARDA, IRRI and AVRDC.

3.7 Regeneration

As aging of conserved accessions occurs even under optimal *ex situ* storage conditions, periodical monitoring of the viability and timely regeneration of materials are an essential, though often neglected, part of *ex situ* conservation. Limited financial resources, infrastructures and human capacity still represent the main constraints to regeneration, as was reported in the first SoW report. The need for skilled staff is especially great in the case of difficult and poorly researched species, such as many of the crop wild relatives. The crop and regional conservation strategies supported by the Global Crop Diversity Trust have highlighted the fact that regeneration backlogs occur in all types of conserved germplasm and in all regions[23]. According to information on NISMs databases,[24] since 1996 capacity has worsened in 20% of the surveyed genebanks, regeneration backlogs have persisted in 37% of them and in 18% they have increased. Regeneration and documentation updating efforts are currently being supported by the GCDT in 40 countries for about 100,000 accessions in collections identified as being the highest priority by crop experts.

Africa
Regular viability testing was carried out in Madagascar, Nigeria, Uganda and Zambia, but generally not elsewhere. The systematic regeneration of stored material appears sporadic, although Ethiopia reported regular regeneration of germplasm when viability fell below 85%. Funding, staffing and facilities were frequently reported to be inadequate to allow the necessary germplasm regeneration to be undertaken. On-going regeneration backlogs have been reported for the fonio and sorghum national collections in Mali, as well as for cereal and vegetable collections held at ISRA-URCI in Senegal and at IBC in Ethiopia. The national genebank of Tanzania also warned about a decreasing capacity to manage regeneration needs which resulted in growing backlogs for both cross- and self-pollinated crop collections.

Americas
Viability testing in Argentina was not carried out as regularly as desired, but a considerable amount of regeneration has been done since the first SoW report was published. Bolivia, Cuba, Ecuador, Uruguay, Venezuela and Peru also reported having carried out viability testing and regeneration, but many problems were reported including lack of finance, staff and equipment. On-going backlogs were reported for vegetatively propagated species *inter alia* by INIA Carillanca (Chile), INIAP-DENAREF (Ecuador), INIA-Maracay (Venezuela), INIFAT and the Centro de Bioplantas (Cuba). Important field collections such as the coffee collection held at CATIE are also in need of regeneration and in Brazil, regular seed regeneration is still recognized as a bottleneck for many active collections especially of cross-pollinated species.

Asia and the Pacific
Many of the Asian country reports provided little information on regeneration. While many countries practiced regeneration, it was frequently made difficult due to lack of funds and facilities. Vietnam reported the loss of entire collections. Some countries including Sri Lanka and Philippines were able to carry out regular viability testing of stored germplasm, but this was not always possible in other countries. Regeneration backlogs for vegetatively propagated crops were reported *inter alia* by PGRC (Sri Lanka), SKUAST and CITH (India), FCRI-DA (Thailand) and LAREC (Vietnam), while for cross-pollinated species by DOR (India) and PCA-ZRC (Philippines). Systematic regeneration of all crop germplasm, including fruits, was reported by New Zealand.

Europe
While viability testing was carried out regularly in most countries, the country reports contained few details. There were differences among countries regarding the level to which viability was allowed to fall before regeneration was considered necessary. Iceland, Norway and Sweden specified 60%, while Russian Federation used a value of 50% and Poland a value between 80 and 85%. In general there were no major problems reported from European countries regarding regeneration, although Finland indicated that in some cases small amounts of seeds made regeneration difficult. Notwithstanding an overall increase in capacity to perform regeneration, Armenia reported urgent regeneration needs and growing backlogs for its cereal and vegetatively propagated collections.

Near East
Uzbekistan reported some loss of accessions arising from reduced viability. Many countries have faced difficulties in ensuring the genetic integrity of cross-pollinated species is maintained during regeneration. Cyprus, Egypt, Iran and Pakistan reported having regenerated more than 50% of the accessions stored in their national genebanks. The main genebanks in Morocco, Kazakhstan and Uzbekistan have undertaken substantial regeneration efforts, while the other genebanks in these countries have only carried out limited regeneration activities. There is a need to regenerate the entire wheat collections held in the national genebanks of Azerbaijan, Tajikistan and Turkmenistan.[25]

3.8 Documentation and characterization

The first SoW report highlighted the poor documentation available on much of the world's *ex situ* plant genetic resources. This problem continues to be a substantial obstacle to the increased use of PGRFA in crop improvement and research. Where documentation and characterization data do exist, there are frequent problems in standardization and accessibility, even for basic passport information.

Nonetheless there has been an overall improvement in the accessibility of information, with a number of national genebanks having published collection data on-line or in the process of doing so. In many cases these information systems also permit the ordering of materials on-line. However, a significant imbalance exists among regions and countries within regions. The large majority of countries do not yet maintain an integrated national information system on germplasm holdings. According to the country reports and the NISM data, important *ex situ* holdings in at least 38 countries are still documented at least partially on paper (16 countries) and/or in spreadsheets (32 countries).[26] Dedicated information management systems for *ex situ* collections are used to manage passport and characterization data in only 60% of the countries that provided information on this topic, while generic database software is used in about 34% of countries.

The lack of a freely available, flexible, up-to-date, user-friendly, multi-language system has constrained documentation improvement in many countries, although in some cases regional and/or bilateral collaboration has helped to meet information management needs by sharing experiences and tools.

Almost all the CGIAR centers have developed their own documentation systems that, in most cases, include characterization data as well as an on-line ordering system. They contribute data to the System-wide Information Network on Genetic Resources (SINGER), which holds passport, collecting mission and distribution data on CGIAR and AVRDC collections.[27] An indication of the level of characterization of the collections held by these centres is reported in Table 3.6

Table 3.6 Extent of characterization for some of the collections held by CGIAR centres and AVRDC

Crop Groups	Percent of Accessions Characterized	Total Number of Accessions	Reporting Centres
Cereals[28]	88	292,990	6
Food legumes	78	142,730	4
Vegetables	17	54,277	1
Fruits (banana)	44	883	2
Forages	45	69,788	3
Roots and tubers	68	25,515	3
Total	**73**	**586,193**	**11**

Source: CGIAR System-wide Genetic Resources programme (SGRP) 2008

The extent to which selected national germplasm collections have been characterized and evaluated is given in Table 3.7, based on data from 40 countries and 262 stakeholders. It is evident that while most crop commodity groups have been substantially characterized morphologically, relatively little biochemical evaluation has been done. Among the crop commodity groups, fiber crops and spices have been the most extensively characterized and evaluated, while biochemical evaluation has been chiefly carried out in oil crops and spices.

Table 3.7 Average extent of characterization and evaluation of national collections from 40 countries[29]

Crop Groups	Percent of germplasm holdings					Total number of	
	Characterized	Evaluated				Accessions	Reporting countries
	Morphologically	Agronomically	Biochemically	for abiotic factors	for biotic factors		
Cereals	63	44	10	13	23	410,261	34
Food legumes	67	56	14	13	20	139,711	33
Vegetables	65	44	12	7	14	48,235	27
Oil crops	63	42	52	11	17	40,700	18
Fiber crops	89	84	9	19	18	37,879	15
Fruits, nuts and berries	66	54	12	24	30	31,838	26
Forages	43	50	15	13	15	27,120	20
Roots and tubers	66	54	13	17	24	22,834	27
Spices	82	81	39	7	22	17,755	10
Stimulants	53	64	20	22	35	10,413	15
Sugar crops	46	80	22	36	57	6,413	14
Medicinal plants	65	64	24	11	43	3,744	7
Ornamental plants	74	23	0	48	47	2,622	8
Others	34	85	3	8	22	20,189	11
Total	**64**	**51**	**14**	**14**	**22**	**819,528**	**40**

Sources: National Information Sharing Mechanisms on PGRFA, 2004, 2006, 2007, 2008

The Crop Strategies[30] sponsored by the GCDT contain information relevant to documentation and characterization on a crop basis. For wheat, most developed and developing countries have computerized management systems and many provide web-based access to information on characterization and documentation, but the major problem is the lack of standardization among existing systems. A similar problem is evident for maize, in that there are passport data for most accessions in most collections, but there is little uniformity in its management. Tracing materials through donor collection identifiers is generally quite difficult in web-accessible information systems. For barley some characterization information is available on the web, but few evaluation data are available electronically.

Electronic documentation of potato is mostly only partially complete and few genebanks are able to provide characterization and evaluation data through their own websites. For sweet potato a similar situation prevails and there is considerable inadequacy in documentation and characterization information and its availability, particularly in Africa. For banana, however, the research community is well served regarding information management and retrieval, and there is an effective information exchange network managed through INIBAP. The *Musa* Information System contains information on more than 5,000 accessions managed in 18 of the approximately 60 collections. A similar information system has been put in place for rice by IRRI.

For the pulses a considerable amount of evaluation and documentation still remains to be done and standardized global information systems are needed for most of them. Currently, data and information on these crops are sparse and scattered and what little information is available is often not available electronically.

The following sections describe the status of documentation in the various regions based mainly on information contained in the country reports.

Africa
Most African nations generated characterization and evaluation data on their collections, but with some exceptions (e.g. most SADC countries, Ethiopia, Kenya, Mali), it was generally reported to be incomplete and not standardized. Togo indicated that its documentation was at a rudimentary state and several other countries reported serious weaknesses. However, the level of morphological characterization is high for Ethiopia's collections of cereals, pulse and oil crops (97%), Mali's collections of cereals and vegetables (99%)[31] and Senegal's collections of groundnut (100%). Ninety percent of Ghana's important cocoa collection is characterized for morphological traits, 10% using molecular makers, and 80% evaluated agronomically and for biotic stresses[32]. Several countries including Kenya, Malawi and Namibia reported having generated morphological characterization data, but agronomic and particularly molecular characterization data were scarce across Africa. Generally it was apparent from the country reports that a considerable amount of work is still needed in many countries. Kenya reported its intention to develop national documentation systems that are in line with the SADC SDIS system in use in all SADC countries. While three countries still store some data on paper (Cameroon, Benin, Congo) and eight use spreadsheets, at least eight have dedicated electronic systems (Ethiopia and SADC countries) and three (Kenya, Ghana and Togo) make use of generic databases to manage information on *ex situ* collections.

Americas
A significant amount of information is publicly available with regard to *ex situ* holdings in North America. In particular, detailed passport information is freely accessible through the web-based GRIN[33] on more than half a million accessions of more than 13,000 species stored in 31 genebank repositories of the USDA NPGS. In addition more than 6.5 million

observations are available on various morphological and agronomic traits for 380,000 accessions. Canada GRIN-CA has also adopted this information system.[34]
Country reports from South America indicate that documentation and characterization systems are working relatively well and that electronic databases containing comprehensive data on germplasm accessions are commonly used. Chile, Paraguay and Peru, however, reported that paper systems are still in use for some collections and no data from national programmes in the region are accessible via the web. Passport data were generally reported to be available for large numbers of accessions and many countries reported having characterization data on a range of morphological, agronomic, molecular and biochemical traits. DBGERMO developed by INTA Argentina, is a popular dedicated germplasm data management system in the region, being used in Argentina, Chile, Paraguay, Uruguay and by CATIE in Costa Rica. Paraguay expressed the need for DBGERMO to be adopted at a regional level to harmonize data collection and retrieval in the region. SIBRAGEN is the documentation and dissemination system in use by CENARGEN in Brazil. GIS systems for geographical analysis of collected materials are reportedly used in Argentina and Ecuador.

In their country reports, most countries across the Central America and the Caribbean indicated that while documentation of germplasm holdings existed, it was often not standardized. Little information was provided in the country reports on the availability of passport data. Cuba reported that it had characterized its germplasm holdings using morphological, agronomic, molecular and biochemical traits for 51%, 80%, 7% and 6% of accessions respectively.[35] Mexico reported morphological and agronomic characterization for 46% of accessions and Nicaragua for 100%. St. Vincent and the Grenadines said that characterization and evaluation were rarely carried out, but Trinidad and Tobago reported considerable progress in this area. The use of dedicated genebank documentation systems and databases are relatively rare in this region. They are reportedly in use only in Mexico, Cuba, Trinidad & Tobago, and by the genebank at CATIE in Costa Rica. Some genebanks in Mexico are still using paper in addition to electronic filing, and in more than 40% of the reporting countries spreadsheets are the most common tool for data management.

Asia and the Pacific

In their country reports all Asian countries indicated that at least some documentation existed on their germplasm holdings. Passport data were generally available across the region, for the large majority of accessions. Morphological characterization and agronomic evaluation data were also reported to be widely available; for example Japan has compiled a full complement of characterization data, and characterization and evaluation data are available on 74% and 73% respectively of the Indian germplasm and the equivalent figures for Philippines are 40% and 60% respectively. While India also maintains molecular characterization data on 21% of its accessions, only 3% of total holdings of Malaysia, Philippines, Sri Lanka, Thailand and Viet Nam have any molecular characterization data on them, and these are mainly food legume and cereal crops. A number of countries including Malaysia, the Philippines and Thailand also reported using biochemical markers. About 75% of the reporting countries make use of a dedicated information system for managing *ex situ* germplasm, although in four countries some data have not been put in electronic format yet. China reported having a web-based database, but only in Chinese. Sri Lanka reported the use of a GIS system and together with Bangladesh, Thailand and Vietnam recognized the need for a nation-wide *ex situ* information system. Significant advance in making information on *ex situ* holdings publicly available have been reported by Japan and Korea including passport and characterization data on more than 87,000 accessions held at the National Institute of Agrobiological Resources in Japan[36] and passport data on about 20,000 accessions at the National Agrobiodiversity Centre in Korea.[37]

Country reports from the Pacific suggested that relatively little comprehensive documentation and characterization work has been done. Fiji, New Zealand, Palau, Papua New Guinea and Samoa all reported that documentation existed, but it did not generally follow standard formats. Some information was available in electronic databases, but the Cook Islands, for example, said that development of a database was a national priority. Taro was characterized based on morphological, agronomic and molecular traits in Fiji and Palau, but Samoa had not yet characterized all its accessions to date. Efforts to increase the availability of *ex situ* collections data have been undertaken by Australia and New Zealand through web-based systems. AusPGRIS[38] at present includes passport data on about 40,000 accessions from 229 genera stored at Biloela of the Queensland Department of Primary Industries, and web sites of the Margot Forde Forage Germplasm Centre[39] and the Arable crop genebank and online database[40].

Europe
The state of documentation and characterization is generally good across Europe according to the country reports. Standardized passport data from 38 countries are published by EURISCO,[41] a centralized web-based catalogue managed by Bioversity International since 2003, under the European Cooperative Programme for Plant Genetic Resources (ECP/GR).

Albania, in its country report, did not indicate use of molecular characters, but otherwise applied most morphological and agronomic descriptors using a spreadsheet as the data management tool. However, the data are not freely available. The Nordic countries, Denmark, Finland, Iceland, Norway and Sweden, approached the issue of documentation and characterization in a standard way and all provided information through NordGen, using the Sesto System,[42] which Macedonia reported it was ready to adopt. Croatia and Cyprus reported not yet having compiled characterization data, although passport data were recorded for most accessions. A variety of tools are used for data storage and management, among which spreadsheets and generic databases were the most common.

Near East
Good progress has been made since 1996 on documentation for the main genebanks, in particular in Egypt, Jordan, Morocco, Pakistan, Syria and Turkey, where existing germplasm information has been completely recorded in a dedicated system that is supported technically by ICARDA and Bioversity International. Significant progress has also taken place in Azerbaijan with the inclusion in EURISCO of passport data from the national genebank, and by digitalizing characterization and evaluation data for more than 60% of *ex situ* cereal accessions and 50% of fruit and fiber accessions[43]. Other countries, including Lebanon and Kazakhstan, reported that documentation was not systematic or standardized, although Lebanon reported that evaluation data for vegetables are available via HORTIVAR.[44] Iraq and Kazakhstan reported using crop registers in paper format and Tajikistan reported that a joint computerized system was being devised with Kyrgyzstan. Egypt maintains documentation on all germplasm accessions and has substantial amounts of data on morphological and molecular characterization, as well as on agronomic evaluation. Activities on characterization and evaluation of genetic resources with standard descriptors have advanced in almost all countries in the region and in some of them these have been enriched with molecular characterization data from academic studies. Breeding programmes in Egypt, Iran, Morocco, Pakistan, Syria, Tunisia and Turkey carried out germplasm evaluation for resistance and tolerance to biotic and abiotic stresses and for quality attributes for a wide range of species.

3.9 Germplasm movement

Information on germplasm movement provides a valuable indicator of the use of plant genetic resources (see also Chapter 4). However, such information often remains unavailable and only limited information was available in the country reports. Restrictions on germplasm movements due to international agreements have also been reported. However, more information is now available on this important issue than was the case at the time the first SoW report was published.

Genebanks play a central role in the movement of germplasm within and among countries. Germplasm movement includes exchange among genebanks, sometimes as part of repatriation agreements, material collected in field collecting missions, acquisitions by genebanks from research and breeding programmes, and distribution to plant breeders, researchers and directly to farmers.

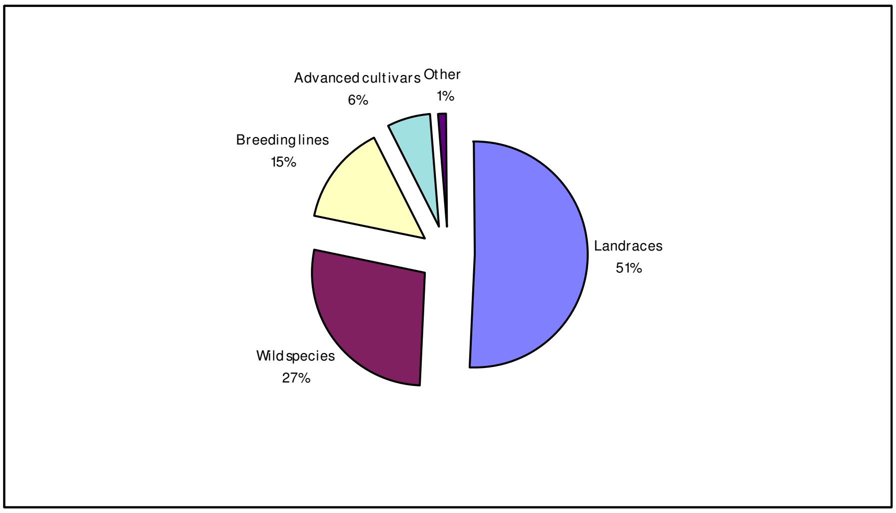
While some information is available on total numbers of samples moved, this is often not broken down into the different crops or types of germplasm concerned, or the nature of the recipient institution. More detailed information on factors such as these would provide for a better understanding of patterns of use. Figure 4.1 in Chapter 4 provides an indirect estimate of germplasm exchange, where sources for breeding activities at the national level are reported.

The ability of a potential recipient to access a particular accession is often limited by the size of a stored sample and its phytosanitary status. Furthermore, inadequate information systems often preclude the possibility of accessing the same accession elsewhere.

Comprehensive data on germplasm acquisition and distribution are available only for the international genebanks. Over the past 12 years the CGIAR Centres and AVRDC have distributed more than 1.1 million samples, 615,000 of which, i.e. about 50,000 per year, went to external recipients. In general, total distribution has remained steady over the period from 1996 to 2007 at about 100,000 accessions each year, although it peaked in 2004. This is similar to the period from 1993 to 1995 as reported in the first SoW report, when about 50,000 accessions per year were also distributed to recipients outside of the CGIAR.

In terms of the types of germplasm distributed by the IARCs, Figure 3.7 shows that the largest proportion are landraces, followed by wild species and breeding lines.

Figure 3.7 Distribution of germplasm held by the IARCs by type of germplasm (1996-2007)

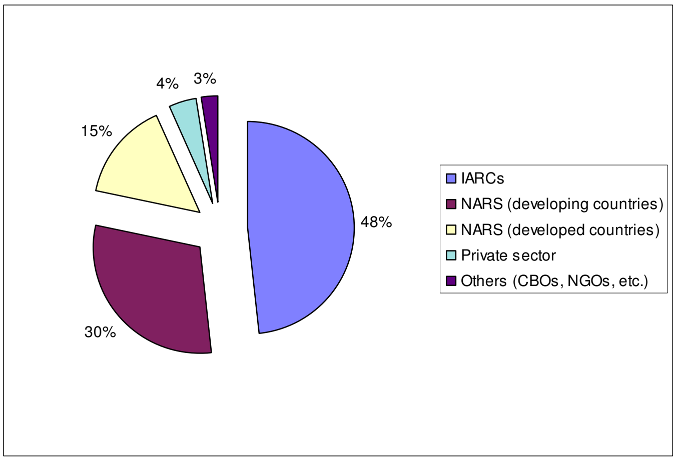


Source: CGIAR System-wide Genetic Resources Programme (SGRP) 2008

Figure 3.8 shows the distribution of germplasm by the IARCs to different types of recipient organization. Nearly half the germplasm was distributed within or between the Centres themselves and 30% went to developing country NARS. Developed country NARS received 15% and the private sector 3%. Breeding materials and advanced cultivars went mainly to

NARS in developing countries, whereas developed country NARS requested mainly landraces. Wild species were equally requested by most organizations.

Figure 3.8 Distribution of germplasm from the IARCs to different types of recipient organization between 1996 and 2007



Source: CGIAR System-wide Genetic Resources Programme (SGRP) 2008

The following sections describe the status of germplasm movement on a regional basis, based on information contained in the country reports.

Africa

Data on germplasm movement were scarce from Africa. Uganda indicated that there was no national monitoring system for germplasm movement in place and Mali reported that germplasm movement was poorly documented. Both Ghana and Guinea said that there was considerable movement, but no figures were available. A significant increase in germplasm movement since 1996 was reported by Malawi, which distributed more than 1,000 accessions and Kenya which distributed 3,189 accessions over the past five years. In its country report, Ethiopia estimated that an average of 5,000 samples were distributed annually to national programmes.

Asia

Little detailed information on germplasm movement was also reported from Asia, but China has distributed 250,000 accessions within the country since 1998 while India has distributed more than 164,000 accessions over the past ten years. Japan distributed more than 36,000 samples in country and about 1,300 abroad over the period 2003-2007, while Pakistan, since 1996, has supplied some 13,000 samples to national institutions and more than 5,000 to international organizations.

Europe

The extent of germplasm movement in Europe and the availability of the relevant data on it varied considerably among countries. Cyprus indicated that there was little public awareness of the existence of its genebank, and hence few requests for germplasm – a problem that is likely to be more widespread than just in Cyprus. While Romania also reported little movement of germplasm, Germany said in its country report that since 1952 IPK had distributed about 710,000 samples to various users with, for example, more than 13,000 samples being distributed in 2006 alone. Between 1985 and 2003, 140,000 samples were requested from the BAZ genebank in Braunschweig. Poland distributed between 5,000 and 10,000 samples annually between 1996 and 2007, and Switzerland distributed annually an average of 270 samples nationally and internationally.

Near East
Jordan reported that most germplasm movement occurred among farmers – a situation that is also likely to occur in many other countries of this region and others. However it is difficult to assess the importance of farmer-farmer exchanges in terms of the overall distribution of genetic diversity nationally, regionally and internationally. There was otherwise little information from this region.

3.10 Botanical gardens

There are over 2,500 botanical gardens worldwide that together grow over 80,000 plant species (approximately one third of all known plant species).[45] As well as their living collections, botanical gardens often have herbaria and carpological collections, and an increasing number have seed banks and *in vitro* collections.

In the last ten years, the number of botanical gardens recorded in Botanic Gardens Conservation International's global database increased from 1,500 to 2,561[46], at least partly reflecting the current trend for establishing new botanical gardens in many parts of the world. In its country report, China indicated that it had 170 botanical gardens and India reported 150. Russian Federation reported that it had about 70 botanical gardens, Germany 95, Italy 102 and Mexico 30, while most other countries had less than ten. Botanical gardens often maintain very substantial germplasm holdings. The German botanical gardens together conserve about 250,000 accessions of 5,000 taxa and those of Russian Federation about 50,000 taxa.

Botanical gardens are diverse institutions; many are associated with universities and focus on research and teaching (as mentioned in 19 country reports), while others may be governmental, municipal or private. Throughout their history, botanical gardens have been concerned with cultivating plants of importance to humankind for medicinal, economic and ornamental purposes. In recent years, the focus of many gardens is turning to the conservation of native species (as mentioned in 19 country reports), especially those under threat of extinction in the wild. Many of these species are either of direct socio-economic importance to local communities or are crop wild relatives; both are groups that tend to be less well represented in traditional collections of PGRFA.

The Global Strategy for Plant Conservation (GSPC)[47] of the Convention on Biological Diversity (CBD) provides a global framework for conserving plants and includes some measurable targets. Botanical gardens played a key role in developing the strategy and are expected to be important contributors to its implementation. Other international organizations, including Bioversity International, FAO and IUCN, have also been identified as lead international partners for specific targets, with a role in supporting country implementation of the Strategy. In some countries, stakeholder consultations held to develop national responses to the GSPC have been successful in bringing the botanical garden and environmental sectors together with the agricultural sector, forging closer linkages on the conservation of PGRFA. However, in many countries cross-sectoral linkages remain poorly developed and botanical gardens are not generally included in national PGR programmes or networks. Despite this, botanical gardens are mentioned as being involved in plant conservation by 98 countries and the country reports of Kenya, Uganda and Zambia specifically note that botanical gardens are included in their national PGR networks.

3.10.1 Conservation facilities, statistics and examples

The majority of botanical gardens are located in Europe (36%) and the Americas (34%) with 23.5% in Asia and the Pacific and only 5.5% in Africa. Worldwide, over 800 botanical gardens specifically focus on conservation, and their *ex situ* collections include a wide range of socio-economically important species. Crop wild relatives (CWR) are well represented in botanical garden collections with, for example, over 2,000 CWR taxa in botanical gardens in Europe. Further details on CWRs in botanical garden collections are provided in Table 3.8. Similarly, some 1,800 medicinal plant taxa are represented in botanical garden collections globally.[48]

Table 3.8 Botanical garden collections of selected crops listed in Annex 1 of the ITPGRFA[49]

Crop	Genus	Number of species recorded in PlantSearch
Breadfruit	*Artocarpus*	107
Asparagus	*Asparagus*	86
Brassica	13 genera	122
Chickpea	*Cicer*	16
Citrus	*Citrus*	18
Yams	*Dioscorea*	60
Strawberry	*Fragaria*	16
Sunflower	*Helianthus*	36
Sweet potato	*Ipomoea*	85
Grass pea	*Lathyrus*	82
Apple	*Malus*	62
Pearl Millet	*Pennisetum*	23
Potato etc.	*Solanum*	190
Sorghum	*Sorghum*	15
Wheat	*Triticum*	23
	Agropyron	9
	Elymus	36
Faba bean/vetch	*Vicia*	77
Cowpea *et al.*	*Vigna*	12

Source: Modified from Sharrock, S. and D. Wuse Jackson. 2008

Ex situ conservation in botanical gardens tends to focus on living collections, and in this regard they can play a useful role in the conservation of vegetatively propagated species, those with recalcitrant seeds and tree species. In Poland's country report, for example, specific mention is made of the conservation of apple germplasm by a botanical garden. However, seed conservation is important for some botanical gardens and at least 160 gardens around the world have seed banks. The Millennium Seed Bank Project (MBSP) of the Royal Botanical Gardens, Kew, is the largest and together with its partners around the world, aims to conserve seed of 24,200 species by 2010, with a particular focus on dryland species. China's largest seed bank, the Germplasm Bank of Wild Species (GBWS), is located at the Botanical Garden of the Kunming Institute of Botany. In Europe, ENSCONET (European Native Seed Conservation Network) brings together the seed conservation activities of over twenty European botanical gardens and other institutes. Through this network, seeds are conserved of nearly 40,000 accessions of more than 9,000 native European plant taxa.[50]

3.10.2 Documentation and germplasm exchange

Six hundred and ninety-six botanical gardens have supplied plant collection records to BGCI for inclusion in the global PlantSearch database, which includes some 575,000 records for around 180,000 taxa[51] in cultivation in botanical gardens worldwide. However, this information consists of species names only and does not include descriptive information or country of origin of accessions. At the national level, some countries have developed national databases of plants in cultivation in botanical gardens that provide more detailed accession information. These include PlantCol in Belgium[52], SysTax in Germany[53], and the Dutch National Plants Collection[54]. In the USA, the Plant Collections Consortium aims to bring together information on collections in 16 US institutions and 4 international institutions[55]. In the UK, the Electronic Plant Information Centre (ePIC) developed by the Royal Botanical Gardens, Kew, provides a single point of search across all Kew's major specimen, bibliographic and taxonomic databases. Kew's Seed Information Database is included in ePIC, which is an on-going compilation of species' seed characteristics and traits, both from the MSBP's own collections and from the published and unpublished data of many seed biologists worldwide.[56]

One of the main international mechanisms for the exchange of germplasm between botanical gardens is the germplasm catalogue, the *Index seminum*. While still popular in Europe, concerns over the potential spread of invasive species have limited the use of the *Index seminum* in the USA. In Europe, the International Plant Exchange Network (IPEN) was developed as a response to the Access and Benefit Sharing provisions of the CBD to facilitate the exchange of germplasm for non-commercial use.[57]

3.11 Changes since the first SoW report was published

While significant advances have been made over the period since the first SoW report was published, in almost all areas further work is needed. Major changes include:

- More than 1.4 million germplasm accessions have been added to *ex situ* collections, bringing the total number now conserved worldwide to about 7.4 million. The majority of these are maintained in seed genebanks;
- More than 240,000 new accessions have been collected and are now being conserved *ex situ*. This number, however, is believed to be a considerable underestimate in that many countries did not provide figures on the number of accessions collected;
- Fewer countries account for a larger percentage of the total world *ex situ* germplasm holdings than was the case in 1996;
- Interest in collecting and maintaining collections of crop wild relatives is growing as land-use systems change, concerns about the effects of climate change grow and techniques for using the material become more powerful and more readily available;
- Interest is also growing in neglected and underused crops in recognition of their potential to produce high-value niche products and as novel crops for the new environment conditions that are expected to result from climate change;
- Significant advances have been made in regeneration: at the international level as a result of funding provided to the CGIAR Centres for the ' Global Public Goods' project, and at the national level as a result of a significant project by the Global Crop Diversity Trust. However, much more remains to be done;
- The collections of documentation and characterization data have progressed, although there are still large data gaps and much of the existing data is not accessible electronically;

- The Global Crop Diversity Trust, founded in 2004, represents a major step forward in underpinning the world's ability to secure PGRFA in the long-term; and
- With the establishment of the highly innovative Svalbard Global Seed Vault, a last resort safety back-up repository is now freely available to the world community for the long-term storage of duplicate seed samples.

3.12 Gaps and needs

The overall needs of *ex situ* conservation remain largely the same as those listed in the first SoW report. This does not suggest that good progress has not been made, but that progress has not been complete and that many of the most important constraints can only be addressed through long-term commitments. Continuing gaps and needs include:

- Many countries, although aware of the importance of conserving plant genetic resources *ex situ*, do not have adequate human capacity, funds or facilities to carry out the necessary work to the required standards. Many valuable collections are in jeopardy because their storage and management are sub-optimal;
- Greater efforts are needed to build a truly rational global system of *ex situ* collections. This requires, in particular, strengthened regional and international trust and cooperation;
- While there are still high levels of duplication globally for a number of crops, especially major crops, much of this is unintended and many crops and important collections remain inadequately safety duplicated. The situation is most serious for vegetatively propagated species and species with recalcitrant seeds;
- In spite of significant advances in the regeneration of collections, many countries still lack the resources needed to maintain adequate levels of viability;
- For several major crops, such as wheat and rice, a large part of the genetic diversity is now represented in collections. However, for many other crops, especially many neglected and underused species and crop wild relatives, comprehensive collections still do not exist and considerable gaps remain to be filled;
- To better serve the management of collections and encourage an increased use of the germplasm, documentation, characterization and evaluation all need to be strengthened and harmonized and the data need to be made more accessible. Greater standardization of data and information management systems is needed;
- *In situ* and *ex situ* conservation strategies need to be better linked to ensure that a maximum amount of genetic diversity is conserved in the most appropriate way, and that biological and cultural information is not lost inadvertently;
- Greater efforts are needed to promote the use of the genetic resources maintained in collections. Stronger links are needed between the managers of collections and those whose primary interest lies in using the resources, especially for plant breeding;
- In the effort to mobilize additional resources for *ex situ* conservation, greater efforts are needed in raising awareness among policy makers and the general public, of the importance of PGRFA and the need to safeguard it.

[1] WIEWS http://apps3.fao.org/wiews
[2] This is roughly 1 accession per 1,000 inhabitants worldwide.
[3] WIEWS http://apps3.fao.org/wiews June 2009
[4] India; United States; China; Brazil; Japan; France; Russian Federation.
[5] The Svalbard Global Seed Vault – see section 3.2 for further information
[6] Excluding specialized genebanks only holding genetic stocks of plant not for food and agriculture.
[7] Country grouping by region and subregion as per Appendix 1 of the SoW-1
[8] More than 41 countries reportedly undertook collecting mission since 1996 though did not provide figures on accessions collected.
[9] Note: Collecting of duplicate samples derived from joint missions are included.
[10] Spooner, DM, & William, KA. (2004) Germplasm acquisition. Encyclopedia of Plant and Crop Science, Marcel Dekker Inc., New York
[11] 31 genebanks of the NPGS of USDA (source GRIN 2008); 234 genebanks from Europe (source EURISCO 2008); 12 genebanks from SADC (source SDIS 2007); NGBK (Kenya) (source: dir. info. 2008); DENAREF (Ecuador) (source: dir. info. 2008); NBPGR (India) (source dir. info 2008); IRRI, ICARDA, ICRISAT and AVRDC (source: dir. info. 2008); CIP, CIMMYT, ICRAF, IITA, ILRI, WARDA (source SINGER 2008).
[12] Crop Strategy Documents for details http://www.croptrust.org/main/strategy.php
[13] It holds the USDA base collection, including 76% of the duplicate material under the National Plant Germplasm System (NPGS).
[14] Among these Argentina, Bolivia, Brazil, Uruguay, Venezuela.
[15] Including wild forms of the same species as the domesticate, wild species related to the domesticate, and weedy/semi-wild or minimally cultivated species that comprise part of the crop genepool
[16] Total number of accessions whose country of origin is reported.
[17] Crop Strategies, http://www.croptrust.org/main/strategy.php
[18] "DNA banks - providing novel options for genebanks?" ed. M. Carmen de Vicente and Meike S. Andersson, pub. Bioversity International (formerly IPGRI), 2006, http://books.google.com/books?id=B8Of_QoxRXEC
[19] Engelmann, F. (2004) Genetic Resource Conservation of Seeds. Encyclopedia of Plant and Crop Science, Marcel Dekker Inc., New York.
[20] Gómez-Campo, C. (2007) A guide to efficient long term seed preservation. Monographs ETSIA, Univ. Politécnica de Madrid 170, 1-17.
[21] Global Strategy for the Ex Situ Conservation and Use of Barley Germplasm (2008), http://www.croptrust.org/documents/web/Barley_Strategy_FINAL_27Oct08.pdf
[22] The Global Crop Diversity Trust, www.croptrust.org
[23] Koury, C., Laliberté, B. and Guarino, L. 2009. Trends and Constraints in *Ex Situ* Conservation of Plant Genetic Resources: A Review of Global Crop and Regional Conservation Strategies (http://www.croptrust.org/documents/WebPDF/Crop%20and%20Regional%20Conservation%20Strategies%20Review.pdf)
[24] NISM databases from 47 countries and based on replies from 240 genebanks (www.pgrfa.org/gpa)
[25] CIMMYT, 2007. Global Strategy for the *Ex Situ* Conservation with Enhanced Access to Wheat, Rye and Triticale Genetic Resources (http://www.croptrust.org/documents/web/Wheat-Strategy-FINAL-20Sep07.pdf)
[26] 115 stakeholders from 32 countries reportedly store *ex situ* holdings information in MS Excel (NISMs, www.pgrfa.org/gpa)
[27] SINGER, www.singer.grinfo.net
[28] Information for the wheat collection held at CIMMYT is not available.
[29] Argentina; Armenia; Azerbaijan; Benin; Bolivia; Chile; Congo, Republic of; Costa Rica; Cuba; Czech Republic; Dominican Republic; Ecuador; El Salvador; Ethiopia; Ghana; Guatemala; Guinea; India; Kazakhstan; Kenya; Kyrgyzstan; Lebanon; Malawi; Malaysia; Mali; Oman; Pakistan; Peru; Philippines; Portugal; Senegal; Sri Lanka, Dem. Soc. Rep.; Tajikistan; Thailand; Togo; Uruguay; Uzbekistan; Venezuela, Bol. Rep. of; Viet Nam; Zambia.
[30] See various Crop Strategy Documents for details
[31] http://www.pgrfa.org/gpa/eth and http://www.pgrfa.org/gpa/mli
[32] http://www.pgrfa.org/gpa/gha
[33] http://www.ars-grin.gov/

[34] http://pgrc3.agr.gc.ca/search_grinca-recherche_rirgc_e.html
[35] http://www.pgrfa.org/gpa/cub
[36] http://www.nias.affrc.go.jp/index_e.html
[37] http://genebank.rda.go.kr/
[38] http://www2.dpi.qld.gov.au/extra/asp/auspgris/
[39] http://www.agresearch.co.nz/seeds/default.aspx
[40] http://www.crop.cri.nz/home/research/plants/genebank.php
[41] EURISCO, www.ecpgr.cgiar.org/Networks/NCG
[42] http://tor.ngb.se/sesto/
[43] http://www.pgrfa.org/gpa/aze
[44] http://www.fao.org/hortivar
[45] Information from BGCI's global databases (PlantSearch – a database of plants in cultivation in botanical gardens and GardenSearch – a database of botanical gardens worldwide. Available at www.bgci.org)
[46] BCGI 2009 http://www.bgci.org/garden_search.php
[47] CBD (2002) Global Strategy for Plant Conservation (GSPC). Secretariat of the Convention on Biological Diversity, Montreal, Canada.
[48] Information from BGCI's PlantSearch database
[49] Sharrock, S. and D. Wuse Jackson. 2008. The role of botanical gardens in the conservation of crop wild relatives. In: Crop wild relative conservation and use. Eds. Maxted, N., B.V. Ford-Lloyd, S.P. Kell, J.M. Iriondo, M.E. Dulloo and J. Turok. CAB International, UK.
[50] Further information: www.ensconet.eu/.
[51] Data correct as at March 2009.
[52] www.plantcol.be/index.php
[53] www.biologie.uni-ulm.de/systax/
[54] www.nationale-plantencollectie.nl/
[55] www.PlantCollections.org
[56] Further information: http://epic.kew.org/index.htm.
[57] Further information: www.bgci.org/resources/abs/

Chapter 4

The state of use

4.1 Introduction

In a world of changing climates, expanding populations, shifting pests and diseases, growing resource scarcity and financial and social turmoil, sustainable use of PGRFA has never been more important or offered greater opportunities. The development of new varieties of crops through plant breeding depends on breeders and farmers having access to the genetic diversity they need to develop varieties with higher and more reliable yields, that have resistance to pests and diseases, that tolerate drought, water-logging, heat, cold and other stresses, make more efficient use of resources, have a longer shelf-life and that produce new and better quality products and by-products. National capacity must be improved to use the collected germplasm.

Of course PGRFA also have many other uses – from direct introduction on farms for production or diversity restoration, to education and scientific research in such areas as gene expression and gene mining. They are also used for land restoration, and traditional and local varieties are often very important socially and culturally. While there is an indication from the country reports that the value of PGRFA in such areas is increasing, this chapter will concentrate mainly on what remains its primary use in breeding new varieties and their dissemination to farmers. It provides an overview of the current state of PGRFA use and describes how the situation has developed since the first SoW report was published. Special attention is paid to the situation in developing countries that, in many cases, still lack the human and financial resources needed to make full use of PGRFA. A summary of the constraints to improved and expanded use is presented in this chapter, with suggestions for how they might be alleviated.

4.2 Germplasm distribution and use

Based on dissemination data of germplasm from genebanks, it is possible to see the trends in the extent to which PGRFA are used by different groups. Table 4.1 shows the PGRFA movement from the IARC genebanks to users from 1996 to 2006. The values within each column indicate the relative importance of each type of accession for the given class of user. The last column gives the percentage across all classes of users and shows that the IARCs distribute more accessions of land races than all other types of material together, followed by wild species.

Table 4.1 Percentage of accessions of different types of PGRFA distributed by the IARCs to different classes of user from 1996 to 2006

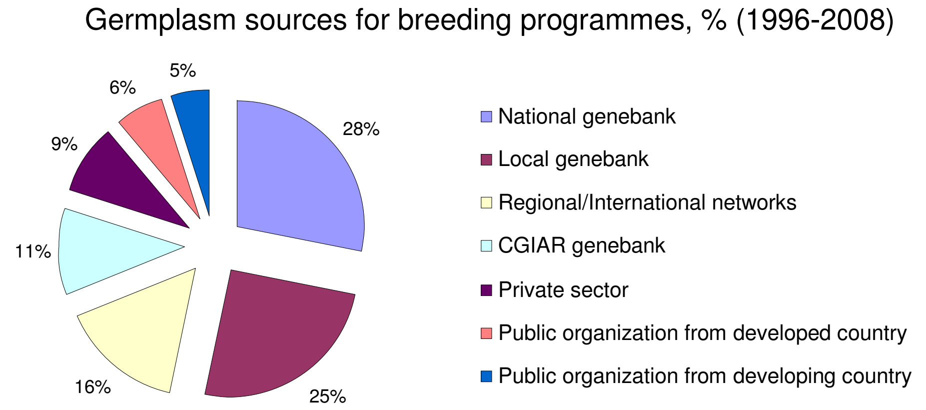
Type of accession	Within / between IARCs	NARS Developing countries	NARS Developed countries	Private sector	Others	Total number of accessions	% of the total
Land races	57.9	48.5	45.0	51.7	65.7	194546	51
Wild species	29.2	19.0	40.5	7.1	19.1	104982	27
Breeding lines	8.5	23.1	5.4	36.0	6.5	56804	15
Advanced cultivars	3.5	8.0	9.1	5.1	8.6	24172	6
Others	0.9	1.4	0.1	0.1	0.1	3767	1

Source: Survey carried out by the System-wide Genetic Resources Programme (SGRP) of the IARCs. The information was requested from the genebank managers; thus it may or may not include material distributed by breeders through their networks.

Comprehensive information on germplasm distribution by national genebanks for a given period is seldom available in the country reports. However, the Japan report indicated that the genebank distributed 12,292 accessions in 2003 and only 6,150 in 2007. In the 5-year period most of the accessions (24,251) were sent to independent corporations or public research institutions within the country, followed by universities (10,935), other countries (1299) and the private sector (995). The report from Poland showed that the number of accessions sent out in 1997 and in 2007 was very similar (some 5,700); nevertheless there was a significant increase in 2002 when some 10,000 accessions were distributed (for regional distribution, see Chapter 3.1).

Although a wide range of genetic resources is available nationally and internationally, breeders often still select the majority of their parental materials from their own working collections and from nurseries supplied by the CGIAR centres. This is largely because of the difficulty of transferring genes from non-adapted backgrounds and the fact that germplasm collections often lack useful characterization or evaluation data. In spite of this, Figure 4.1 indicates that national plant breeding programmes make reasonable use of the genetic resources stored in genebanks.

Figure 4.1 Sources of PGRFA used by breeders working in national breeding programmes[a]



[a] Source: National Information Sharing Mechanism 2008 – www.pgrfa.org/gpa. The figures are based on the response of 268 breeders from 39 developing countries to a question on the origin of the PGRFA used in their breeding programmes.

4.3 Characterization and evaluation of PGRFA

Characterization of PGRFA is the process by which accessions are identified by their unique combination of traits. These traits are usually highly heritable, easily seen by the eye and equally expressed in all environments. The process of characterizing accessions most commonly involves the generation of information on agronomic traits and morphological markers (phenotypic markers). PGRFA accessions can also be characterized using modern biotechnological tools such as molecular markers (genotypic markers). The evaluation of PGRFA, on the other hand, provides data about traits that are generally considered to have actual or potential commercial utility. Often the expression of these traits varies with the environment, so valid conclusions require evaluation in different environments that corresponding to those experienced by the target client groups.

The country reports were virtually unanimous in suggesting that one of the most significant obstacles to greater PGRFA use is the lack of adequate characterization and evaluation data and the capacity to generate and manage such data. Activities to promote greater characterization and evaluation are a major priority of Priority Activity Area 9 of the GPA. More comprehensive data, in terms of both traits and crops, would enable plant breeders and other researchers to select germplasm more efficiently and help obviate the need to repeat screenings. The problem of lack of data extends from a paucity of basic passport and characterization data for many accessions, to a relative lack of publicly available evaluation data for most accessions - even on standard agronomic and physiological traits. While the problem is serious in many collections of major crops, it is most acute for under-utilized crops and wild relatives. Thailand was one of few countries that reported carrying out economic evaluation of its accessions. China called for better evaluation standards, while The Netherlands reported that it had largely harmonized its evaluation data and that these are now available on-line. Spain also reported progress in this area.

An indication of the extent and nature of characterization of germplasm is given in Table 4.2. In general, it appears that the greatest effort goes into characterizing morphological and agronomic traits and that molecular markers have been relatively little used outside the Near East. Abiotic and biotic stresses receive roughly equal attention.

Table 4.2 Traits and methods used for characterizing germplasm: percentage of accessions characterized and/or evaluated using particular methods, or evaluated for particular traits, averaged across countries in each region[a]

Region	No.[b]	Morphology	Molecular markers	Agronomic traits	Biochemical traits	Abiotic stresses	Biotic stresses
Africa	62	50	8	38	9	14	24
Americas	253	42	7	86	23	18	25
Asia and the Pacific	337	67	12	66	20	27	41
Europe	31	56	7	43	8	22	23
Near East	229	76	64	77	57	63	69

[a] Source: National Information Sharing Mechanism 2008 – www.pgrfa.org/gpa. The figures are based on the response of 323 stakeholders from 42 developing countries to a question on the percentage of accessions characterized and/or evaluated for the various traits.
[b] Total number of *ex situ* collections for which characterization data exist

Since the first SoW report, core collections and other collection subsets have become increasingly important as a means of improving the efficiency and efficacy of evaluation. A core collection is a sub-set of a larger collection that aims to capture the maximum genetic diversity within a small number of accessions.[1] While many country reports pointed out the value of well-documented core and mini-core collections to plant breeders,[2] other countries did not consider them useful.[3] The topic was not covered in the first SoW report and several countries suggested that it would be useful to expand the number of core collections to include more crops than at present. However, some countries, for example Bangladesh, stated that there was only limited knowledge about core collections and Sri Lanka reported that core collections 'have not been prepared for any of the crop species … (which) will hinder utilization of the conserved germplasm'. Argentina noted that core collections are useful for pre-breeding and would help increase the use of the country's national collections. However, it also noted that the 'development of core collections … requires broad understanding and characterization of the germplasm'.

Several instances were reported in which core collections have been developed in an attempt to improve the use of PGRFA. In the Americas, the six Southern Cone countries have collaborated in creating a regional maize core collection, made up of independently managed national components. Collectively, this core collection represents a significant percentage of the region's genetic heritage and includes 817 of the 8,293 accessions maintained in the region.[4] In addition to maize, Brazil has assembled core collections on beans and rice, and Uruguay on barley. Other examples include Kenya, which has established a core collection for sesame; Malaysia, which has established ten core collections, including cassava, sweet potato and taro; and China, which has established six core collections including rice, maize and soybean. In Europe, Portugal has maize and rice core collections and Russia has 20 core collections, including wheat, barley and oats. Neither the Near East country reports nor the regional consultation highlighted efforts on core collections.

Table 4.3 indicates the principal perceived constraints to the definition and establishment of core collections. A lack of adequate information on accessions is considered to be the major obstacle. Uganda, for example, stated that at present '… there are no core collections as the PGR accessions held have not been evaluated extensively …'. Lack of funds and personnel are also regarded as a significant hindrance as is an apparent lack of suitable accessions.

Table 4.3 Major obstacles to the establishment of core collections: percentage of respondents in each region who indicated that a particular constraint represented an important constraint in the region[a]

Region	Funds	Lack of personnel	Limited no. accessions	Need not recognized	Limited information on accessions	Poor access to germplasm	Methods too complex	Lack of interest
Africa	100	67	50	17	67	0	8	8
Asia and the Pacific	44	67	44	67	78	33	44	11
Americas	92	75	42	33	75	17	0	8
Europe	100	33	67	33	100	0	0	0
Near East	67	89	67	44	33	22	22	22

[a] Source: National Information Sharing Mechanism 2008 – www.pgrfa.org/gpa. The figures are based on the response of 45 plant breeders from 45 developing countries to a question on the obstacles to establishing core collections in the country.

While core collections remain the most common way to subdivide collections in order to facilitate their evaluation and use, other useful and powerful methods have recently been developed. The Focused Identification of Germplasm Strategy (FIGS), for example, is a methodology that uses geographic origins to identify custom subsets of accessions with single and multiple trait(s) that may be of importance to breeding programmes. This methodology has been established for the combined VIR, ICARDA, AWCC wheat landrace collection, and the database, which is publicly accessible, can be searched using FIGS.[5]

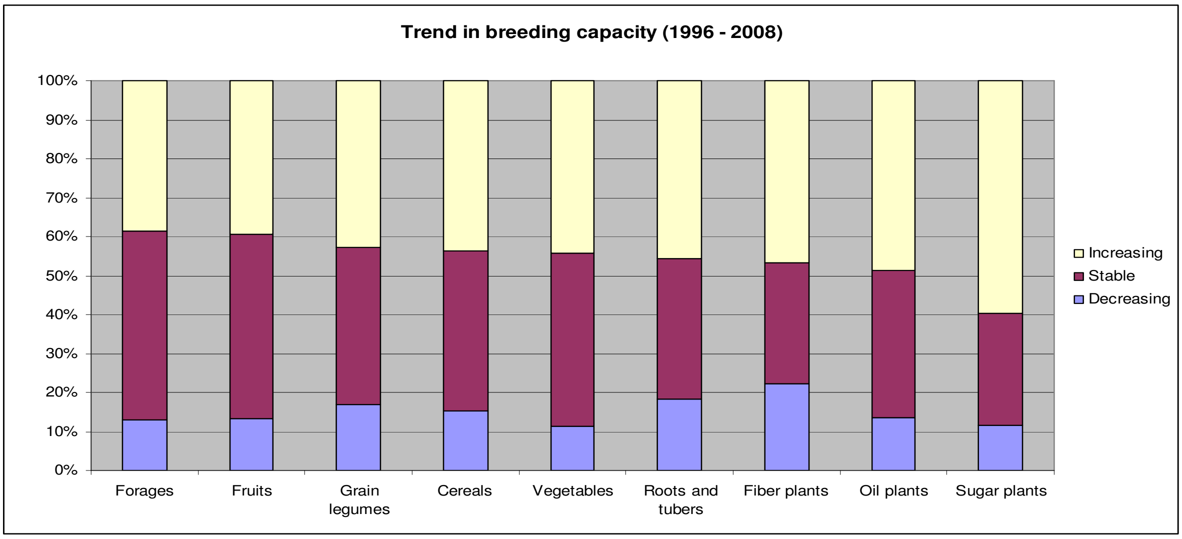
Since the publication of the first SoW report, there have been several new international initiatives that support the increased characterization and evaluation of germplasm. Among them are several activities undertaken by the Global Crop Diversity Trust, and the Generation Challenge Programme of the CGIAR. Both provide additional tools to facilitate the establishment of sub-collections and promote the use of PGRFA, the latter through the application of molecular techniques.

4.4 Plant breeding capacity

There are numerous ways to improve crops genetically, from traditional crossing and selection to the most recent gene transfer techniques. But all of these depend on the ability of plant breeders to assemble genes for the desired traits within new varieties. Recognizing the importance of plant genetic improvement – to keep up with expanding and new demands – most countries support some form of public and/or private plant breeding system. The GIPB[6] assessed plant breeding capacity worldwide and the information assembled is found in the PBBC[7] database. While at the global level the allocation of resources to plant breeding in the past decade has been relatively constant, there is considerable variation among individual countries and among regions. Certain national programmes, for example in Central America and East and North Africa, have reported a modest increase in the number of plant breeders[8] but there has been a decline in others, e.g. in East Europe and Central Asia. Within the rest of Asia there have been decreases in Bangladesh and the Philippines while numbers have risen in Thailand.[9]

The results of a survey looking at trends in plant breeding capacity in developing countries are summarized in Figure 4.2. According to the perception of plant breeders, since 1996 for most crops or crop groups the overall capacity has remained stable or decreased. There appears to be relatively few areas where higher investment has allowed the kind of progress in capacity building to take place that is needed for solving tomorrow's problems.

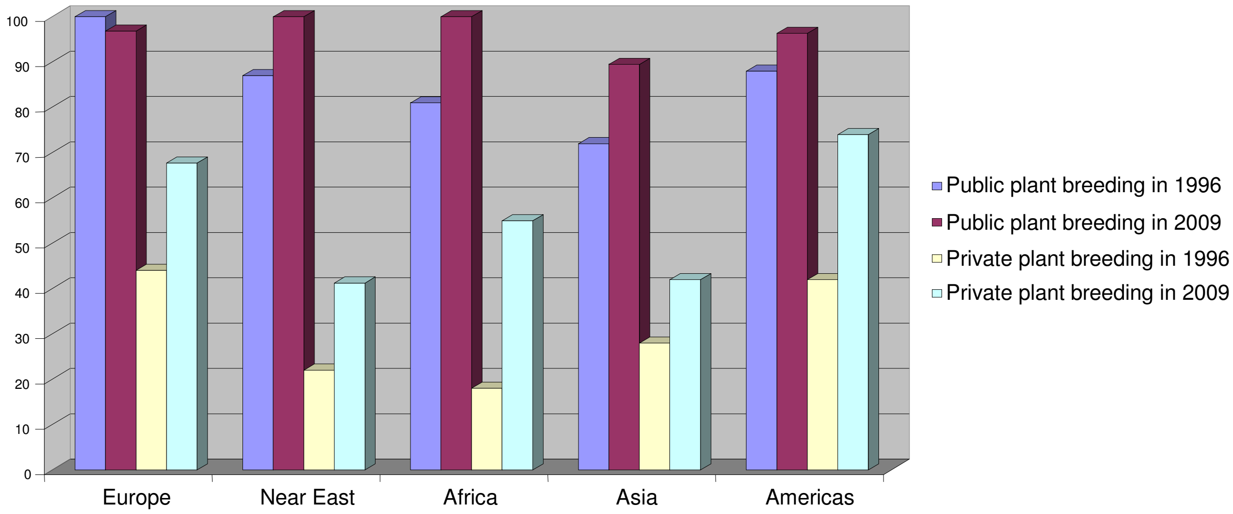
Figure 4.2 Trends in plant breeding capacity; percentage of respondents indicating that human, financial and infrastructure resources for plant breeding of specific crops in their country had increased, decreased or remained stable since the first SoW report[a]



[a] Source: National Information Sharing Mechanism 2008 – www.pgrfa.org/gpa. The figures are based on the response of 404 plant breeders from 49 developing countries to a question on the current trend within the stakeholders' organization in terms of capacity to breed specific crops or crop groups.

Based on information from the country reports and the GIB-PBBC database, a comparison has been made between countries that reported in the first SoW report and a similar set of countries in 2009, with respect to public vs. private plant breeding programmes. Overall there has been an increase in the number of countries reporting the existence of public breeding programmes, except in Europe. The increase is even more impressive for the private sector (see Figure 4.3). Both public and private sectors have shown the highest percentage increase in Africa, indicating that many new programmes were created in this region since the first SoW report. However, while most countries have both public and private plant breeding programmes, there are reports indicating a trend away from the public sector.[10] Even where there has been an increase in resources for public breeding in nominal terms, this often hides a reduction in real terms as a result of inflation and currency devaluation. Resources for field trials and other essential activities are often limiting.[11] In the USA, it has been reported 'the decline in classical plant breeding [over recent years] is likely underestimated because marker development and other breeding related molecular genetics is included in plant breeding data'.[12]

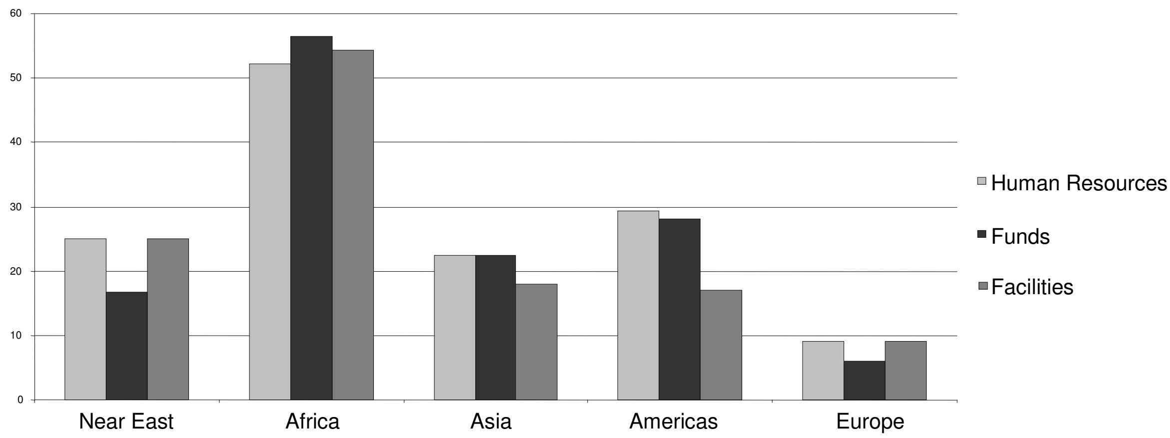
Figure 4.3 Percentage of countries that reported the existence of public and private breeding programmes in the first and second SoW reports[a]



[a] Data from a set of similar countries that presented country reports for both the first and second SoW reports, complemented with information from the GIPB-PBBC database (http://km.fao.org/gipb/pbbc/)

Major constraints to plant breeding, based on NISM reports, are summarized in Figure 4.4. While the data are indicative only and should be interpreted with care, stakeholders in all regions reported constraints in funding, human resources and, with the sole exception of Europe, facilities. The relative importance of these three areas of constraint is unchanged since the first SoW report, as is the fact that the greatest constraints are felt in Africa and the least in Europe.

Figure 4.4 Major constraints to plant breeding: percentage of respondents indicating that a particular constraint was of major importance in their region[a]



[a] Source: National Information Sharing Mechanism 2008 – www.pgrfa.org/gpa. The figures are based on the response of 195 plant breeders from 36 developing countries in 5 regions to a question on the constraints to plant breeding.

In spite of these constraints, many opportunities remain for exploiting the genetic variation in landraces and relatively unimproved populations, using simple breeding techniques or even through direct release. For example, Zambia's country report stated, 'There has been renewed interest in recent years for the need to screen and evaluate local germplasm of major crops' and that there is a '… lack of appreciation of locally available PGR …'. The Lao PDR stated 'Several local landraces of aromatic rice were identified and released for multiplication'. In addition, since the publication of the first SoW report a number of initiatives and legal instruments have been developed to promote the use of PGRFA at national and international levels. Box 4.1 presents some examples.

There appears to have been an increase in the use of wild species in crop improvement, in part due to the increased availability of methods for transferring useful traits from them to domesticated crops. The country report of the Russian Federation stated that crop wild relatives '… maintained and studied at VIR are also valuable as source materials and are often included in breeding programmes …'. However, in spite of their potential importance they remain relatively poorly represented in *ex situ* collections[13] (see Chapters 1.2.2 and 3.3.3).

Biotechnological techniques have evolved considerably over the last ten years and there has been a concomitant increase in their use in plant breeding worldwide. A recent assessment of molecular markers in developing countries, for example, reported a significant increase in their use.[14] A similar trend has been reported in the number of plant biotechnologists in national plant breeding programmes.[15] Molecular characterization of germplasm has also become more widespread across regions and crops, although much remains to be done both to generate more data and make it more readily available. Tissue culture and micropropagation have become routine tools in many programmes, particularly for improving and producing disease-free planting material of vegetatively propagated crops. In the Republic of Congo, micropropagation has been used to propagate threatened edible wild species. Tissue culture methods, important in their own right, are also essential for the application of modern biotechnology in crop improvement. They have become increasingly available in developing countries because of their relatively limited technical requirements and cost.

The use of MAS has also expanded considerably over the past decade and is now employed widely across the developed and developing world.[16] However, it has been used most often for research in academic institutions rather than in crop improvement *per se*. Currently, MAS is mainly used in major crops and for a restricted number of traits, notably in the private sector, although its application is expanding rapidly. Molecular marker based methods have also grown in popularity for use in research on genetic variation at the DNA level. However, molecular characterization of germplasm is still in its early stages and is seldom used routinely because of its high cost and the need for relatively sophisticated facilities and equipment.

According to the country reports, genetically modified (GM) crops are now grown in more countries and on a larger area than was the case a decade ago. However, the number of crops and traits concerned remains small,[17] in large part due to poor public acceptance and a lack of effective biosafety monitoring and other regulations. The most commonly involved traits are resistance to herbicides and insects. Argentina, Brazil, Canada, China, India, South Africa and USA grow the most GM crops - principally soybean, maize, cotton and oilseed rape.[18]

Many developing countries reported that their capacity to apply recombinant DNA techniques in plant breeding remains limited, and even in Europe problems were reported with regard to integrating modern and classical techniques. Portugal, for example, stated '… there is no organized structure that integrates classical (breeding) methodologies with modern ones', whereas Japan reported that modern biotechnologies have become routine in plant breeding.

Numerous new fields of biotechnology have developed over the past decade that can have important applications in plant breeding research and practice - for example in facilitating the understanding of gene function and expression, and the structure and function of proteins and metabolic products. Among these fields are:

- Proteomics – the study of protein expression.
- Transcriptomics – the study of messenger RNA (mRNA).
- Genomics – the study of the structure and functions of DNA sequences.
- Metabolomics – the study of chemical processes involving metabolites.
- Phylogenomics – the study of gene function according to phylogenetics.

In spite of such scientific advances, many programmes, especially in developing countries, are still unable to apply them in practical crop improvement. Not only do they remain expensive and demanding but many are also proprietary. However, it is expected that costs will fall in the future, opening up possibilities for these techniques to be taken up by an increasing number of programmes throughout the world.

4.5 Crops and traits

The crop focus of breeding programmes varies across countries and regions, but there has been little change since the first SoW report.[19] In general, based on data from the country studies and information from the FAOSTAT programme,[20] investment in crop improvement seems to largely mirror the crop's economic importance, thus major crops are still receiving more breeding investments than all other crops. Nevertheless, several country reports highlighted the increased importance of under-utilized crops (see this Chapter, section 4.9.2). As an example, in the Americas region, Latin America invests major resources in improving rice, maize, grain legumes and sugarcane, with some countries - including Ecuador and Uruguay - also devoting considerable efforts to roots and tubers. Coffee, cocoa and fruits also feature strongly. North America concentrates on major food staples, such as maize, wheat, rice and potato, but also invests heavily in improving pasture species, fruits and vegetables. North America and Brazil now invest heavily in biofuels, as do an increasing number of other countries, including some in Asia. However, in most cases the breeding is for tuning new uses of existing major crops and to a lessen degree new alternative crops such as switch grass. As demand for these crops remains high, it is unlikely there will be any significant change in the amount of breeding effort devoted to them in the foreseeable future.

In Africa, countries in the East and Central region and the coastal areas of West Africa tend to concentrate on breeding maize and roots and tubers, especially cassava, while the Sahelian countries mainly seek improvement in rice, cotton, millet and sorghum. The Near East and North Africa countries allocate substantial resources to improving wheat, barley, lentils, chickpeas, fruits and vegetables while South Asia concentrates on rice but also invests heavily in some industrial and high value crops. Sri Lanka's country report, for example, details the substantial contribution of fruits and vegetables to the national economy. Central Asian countries mainly invest in improving cotton and cereals, particularly wheat, but they are also responding to the expanding market for fruits in Asia. Eastern Europe directs most effort to fruits and vegetables while Central Europe gives greatest attention to cereals such as barley and wheat.

According to the country studies, the principal traits sought by plant breeders continue to be those related to yield per unit area of the primary product. In addition to increasing actual yield potential, particular attention is paid to tolerance, avoidance or resistance to pests, diseases and abiotic stresses. Among the latter, drought, salinity, acid soil and heat are all important in the face of continuing land degradation and the expansion of production onto more marginal land. The priority given to breeding against biotic threats has changed little over the past ten years: disease resistance remains the most important trait, especially for major staple crops. While the potential value of exploiting polygenic resistance has long been recognized, the complexity of breeding and the generally lower levels of resistance that result have meant that many breeders still tend to rely largely on major genes.

Breeding for climate change *per se* did not feature markedly in the country reports, although it was mentioned by a few, including the Netherlands, Germany, Lao PDR and Uruguay. However, a growing interest in the topic is apparent in the scientific literature and some plant breeding programmes are beginning to take it more overtly into account. Of course many address the issue indirectly, particularly through breeding for abiotic and biotic stress resistance, tolerance or avoidance. Breeding for low-input and organic agriculture was also rarely mentioned in country reports, but it too is becoming a focus in some programmes, as is breeding for specific nutritional traits.

Some crops and traits may become the focus of the world's attention when potential catastrophes are foreseen, for example in the case of wheat stem rust that has led to the creation of The Borlaug Global Rust Initiative (BGRI).[21] Recent attention is also being to the epidemic of brown-streak virus in cassava in Eastern and Southern Africa.

4.6 Breeding approaches for use of PGRFA

Plant breeders have at their disposal a series of breeding approaches for crop improvement and where capacity exists breeders continue applying them effectively. While the first SoW report makes reference to many of them, this report will discuss pre-breeding and base broadening, and participatory plant breeding (highlighted in Article 6 of the ITPGRFA), where significant changes have occurred over the last decade.

4.6.1 Pre-breeding and base broadening

Priority Activity Area 10 of the GPA lists genetic enhancement and base-broadening as priority activities. Pre-breeding was recognized in many country reports as an important adjunct to plant breeding, as a way to introduce new traits from non-adapted populations and wild relatives. Broadening the genetic base of crops to reduce genetic vulnerability was also regarded as important, but in spite of certain progress over the past 10 years and the increasing availability of molecular tools, there is still a long way to go.

Country reports indicated the use of different methods to assess genetic diversity and put in place pre-breeding and base broadening strategies. Disease resistance is the main trait sought, but a few country reports also indicated that new variability was necessary to increase the opportunities to breed for complex traits such as abiotic stresses and even yield potential. For example, Cuba indicated the use of conventional and molecular marker techniques to determine the genetic variability of beans, tomatoes and potatoes and to design strategies to broaden the genetic base of such crops. Tajikistan, in its country report, stated '… participation in international and regional cooperation networks can be an efficient way of broadening the genetic base of the local breeding programmes'. The Brazilian country report presented several examples of the use of wild species to expand the genetic base of different crop species. Box 4.2 shows the case of passion fruit (*Passiflora* spp.) in Brazil.

Pre-breeding occupies a unique and often crucial step between genetic resources in collections and plant breeders. In some countries, plant breeders carry out pre-breeding activities as a matter of course; in others, such as Ethiopia and the Russian Federation, the national genetic resources programme participates strongly. Many of the problems associated with pre-breeding are related to the wider issue of broadening genetic diversity within crops. NISM data addressing obstacles to increasing genetic diversity as well as diversifying crop production are summarized in Table 4.4. It is evident from the table that the most serious constraints relate to marketing and commerce.

Table 4.4 Major obstacles to base broadening and crop diversification: percentage of respondents in each region reporting a particular obstacle as being important[a]

	Policy and legal issues	Marketing and commerce	Obstacles to release of heterogeneous materials as cultivars
Africa	53	86	43
Asia and the Pacific	51	89	30
Americas	53	86	19
Europe	58	83	58
Near East	30	89	20

[a] Source: National Information Sharing Mechanism 2008 – www.pgrfa.org/gpa. The figures are based on the response of 323 stakeholders from 44 countries to a question on the major constraints in the country in broadening diversity in the crops.

4.6.2 Farmers' participation and farmer breeding

PPB is the process by which farmers participate with trained plant breeders and make decisions in a plant breeding programme, while farmer breeding refers to the process that has gone on for millennia whereby farmers themselves slowly improve crops through their own intentional or inadvertent selection.

Based on country reports, farmer participation in plant breeding activities has increased over the past decade in all regions, in line with the aspirations of Priority Activity Area 11 of the GPA. Several countries reported using participatory plant breeding approaches as part of their PGRFA management strategies; Table 4.5 provides examples. Since farmers are in the best position to understand a crop's limitations and potential within their own farming system, their involvement in the breeding process has obvious advantages. These have been noted in many of the country reports.

Several developing countries, including Bolivia, Guatemala, Jordan, Lao PDR, Mexico and Nepal, indicated in their country reports that participatory breeding approaches are the most suitable way to develop varieties adapted to farmers' needs for certain crops. A number of them rely almost exclusively on participatory methods to develop improved varieties. Currently there are national and international organizations (for example, Local Initiatives for Biodiversity, Research and Development (LI-BIRD) and the Working Group on PPB established in 1996 under the framework of the CGIAR System-wide Program on Participatory Research and Gender Analysis (PRGA)) that devote significant resources to promoting and supporting participatory breeding programmes.

In the Near East, 10 of the 27 countries that participated in the regional consultation indicated the use of participatory breeding approaches to improve different crops. In the Americas, the Latin America and the Caribbean regional consultation report indicates 'Participatory breeding activities at the farm level are often mentioned as a priority, in order to add value to local materials and preserve genetic diversity'. Similar statements can be found in the country reports of Asia,[22] Africa[23] and Europe.[24]

In spite of the overall increase in farmer involvement, it has largely remained limited to priority setting and selecting from among finished crop cultivars. This is a similar situation to that pertaining at the time of the first SoW report. India, for example, stated in its country report that 'farmers' participation is highest either at the stage of setting priorities or at the implementation stage'.

Table 4.5 Examples of country reports mentioning the use of participatory plant breeding

Country	Crop
Angola	Maize
Algeria	Barley and date palm
Azerbaijan	Wheat, barley, rice, melon and grape
Benin	Rice and maize
Burkina Faso	Cereals and pulses
Costa Rica	Bean, cocoa, maize, banana, potato and coffee
Cuba	Bean, maize, pumpkin and rice
Dominican Republic	Pigeon pea
Guatemala	Maize
India	Maize, rice and chickpea
Jamaica	Pepper, coconut and pumpkin
Jordan	Barley, wheat and lentil
Lao PDR	Rice
The Netherlands	Potato
Malawi	Bambara groundnut
Malaysia	Cocoa
Mali	Sorghum
Morocco	Barley, faba bean and wheat
Namibia	Millet, sorghum, legumes
Nepal	Rice, finger millet
Nicaragua	Beans, sorghum
The Philippines	Maize, vegetables and root crops
Portugal	Maize
Senegal	Rice
Thailand	Rice and sesame
Uganda	Beans
Venezuela	Local under-utilized crops

In addition to the efforts of trained plant breeders, many farmers around the world, especially small-scale and subsistence farmers, are themselves intimately involved in the improvement of their crops. Indeed, most of the under-utilized crops and a significant proportion of the major crops grown in developing countries are of varieties developed – and in many cases continually improved - by farmers. While the majority of farmer breeding efforts comprise the local exchange of material and selection among and within heterogeneous populations and landraces, cases have also been described where farmers make deliberate crosses and select within the resulting segregating populations.[25]

Farmers and other rural dwellers are involved in improving not only crops, but also wild species. Cameroon, for example, pointed out in its country report that local selection of the wild species African pear (*Dacroydes edulis*) is carried out by farmers to eliminate poor individual plants from the local stands.

In addition to genetic improvement by farmers, some of the country reports mentioned efforts by producers to bring to the attention of consumers the nutritional, cultural and other benefits of locally developed and managed varieties.

However, there are examples of the need for further planning and coordination to make farmer contributions to plant breeding fully effective. Policies and legislation have a significant impact on how farmers can benefit from their involvement in PPB programmes. In a large number of countries varieties can only be registered when complying with specific distinctness, stability and uniformity standards. Seed laws for maintaining and multiplying registered seed also influence how farmers can participate in variety development. Nepal presents an example of how the national varietal release and registration committee of the national seed board supported the release and the custodianship of a landrace. The European Communities Commission Directive accepts, under certain conditions, marketing seeds of landraces and varieties that are adapted to the local conditions.[26]

The integration of participatory plant breeding in the national breeding strategies is still an area that requires attention. Capacity building on the use of participatory breeding approaches, including providing training to farmers, has been a limitation for the growth of this methodology in some countries. The Netherlands, for example, offers training opportunities in this area. Some international organizations such as ICARDA and CIAT also have significant experience in providing participatory breeding training.

4.7 Constraints to improved use of PGRFA

There was wide agreement among stakeholders surveyed on the major constraints to a greater and more effective use of PGRFA (see Figure 4.4). These do not differ greatly from the ones identified at the time the first SoW report was published and similar constraints were mentioned across the country reports.

4.7.1 Human resources

One of the most commonly cited constraints is a lack of adequately trained personnel to carry out effective research and breeding. This is also supported by data in the PBBC database. Not only is there an ongoing need for training in conventional plant breeding, but with the growing importance of molecular biology and information science, the need has grown for capacity building in these areas as well.

Capacity building efforts cannot be effective unless incentives are provided, such as structured career opportunities, to help ensure the retention of experienced staff. As with other constraints, improved international collaboration could help cut training costs and reduce unnecessary duplication of investments. In this regard, the use of regional centres of excellence has been suggested as one means of reducing costs and duplication.[27]

4.7.2 Funding

Plant breeding, seed systems and associated research are expensive and require a long-term commitment of financial, physical and human resources. Success, for both the public and private sectors, is greatly dependent on government support through appropriate policies as well as funds. External development assistance is also essential for keeping many programmes operative. Public investment is particularly needed for improving crops that do not promise substantial short-term economic returns that would motivate private seed companies as well as under-utilized crops and for those areas of research.[28] Many countries reported a decrease in public investment in crop improvement,[29] although a number of donor agencies and philanthropic bodies have increased their commitment to both breeding and germplasm conservation. However, the short-term nature of most grants and awards,[30] and the shifting priorities of donors have meant that funding is frequently not sustained and it has rarely been possible to develop and maintain strong programmes for the periods of time needed to breed and disseminate new varieties. Uganda was one of several countries that indicated that a lack of funds was responsible for sub-optimal levels of germplasm characterization and evaluation.

4.7.3 Cooperation and linkages

Several country reports expressed concern at the lack of fully effective linkages between basic research, breeders, curators, seed producers and farmers. As suggested by Pakistan, 'Weak links between breeders and curators have limited the use of germplasm resources in crop breeding'. However, some countries, such as the Philippines, reported instances of 'close collaboration between breeders and genebank managers…' and cited coconut, sweet potato, yam and taro as examples.

Oman, St. Vincent and Trinidad and Tobago all commented specifically on the weak researcher-breeder-farmer linkages, but many other countries also considered generally weak internal linkages among national bodies to be a problem. This was true in both developed and developing countries; Portugal and Greece, for example, reported similar problems to Senegal and Ghana. Uganda commented that participatory planning and collaboration paid dividends in strengthening internal links.

4.7.4 Information access and management

Problems related to information access and management lie behind many of the constraints to improved and expanded use of PGRFA. Although, according to the country reports, the problem is widespread, it was considered most severe in countries such as Afghanistan and Iraq where much germplasm and information has been lost in recent years. Albania, Guinea, Peru and the Philippines all reported that lack of information and documentation limited the use of PGRFA. Namibia cited a specific problem, which could be widespread, of poor feedback from PGRFA users, who are obliged to return information on accessions received through the multilateral system.

While some countries do not yet enter PGRFA information into electronic databases, others, such as many European countries, have contributed information to regional databases such as EURISCO. Other large databases that contain comprehensive information include the CGIAR's SINGER system and the USDA's GRIN, both of which have accession level data, and the GIPB-PBBC database that contains global information on plant breeding. Several countries, including Germany and New Zealand, reported using comprehensive web-based information systems for major crops while Hungary, the Czech Republic and Spain reported considerable progress in making information available on-line. The Netherlands described a further step beyond evaluation data being accessible on-line, to an on-line knowledge bank for educational purposes. Aiming to strengthen documentation to enhance use, the Caucasus and the Central Asia countries created a regional database in 2007.[31]

Bioinformatics, briefly referred to in country reports as a relatively new subject, was not discussed at all in the first SoW report. For the many countries that experience difficulties with modern electronic information technology, the benefits of bioinformatics are only likely to become available through collaboration with partners having a greater IT capacity.

An effective example of a global information platform to promote use of PGRFA is the Generation Challenge Programme (GCP) Molecular Breeding Platform, which distributes crop research information generated by the GCP partners.

4.8 Production of seeds and planting material

For agriculture to be successful, sufficient good quality seed has to be available to farmers at the right time and at an affordable price. Seed is traded at the local, national and global levels and underpins, directly or indirectly, almost all agricultural production processes. Seed also has a cultural value for many societies and is frequently associated with traditional knowledge.

There is a diversity of means for the farmers to obtain seeds, and they generally do not distinguish different seed systems. Some authors however have classified seed systems into two broad categories; 'formal' and 'informal'. 'Formal' systems involve institutions in both the public and private domain that develop, multiply and market seed to farmers through well-defined methodologies, controlled stages of multiplication and in the framework of national regulations. Seed produced within 'formal' systems is often of modern varieties. The 'informal' system, on the other hand, is that often practiced by farmers themselves who produce, select, use and market their own seed through local, generally less regulated channels. Of course, often a given farmer will resort to either or both of these approaches for different crops or in different seasons. Several countries in Africa, including Benin, Madagascar and Mali reported that the farmer seed sector is dominant nationally, although there is crop specificity, for example 100% of Mali's cottonseed is supplied by the private sector. 'Formal' systems are developing in many emerging economies and the international seed trade is expanding with increasing globalization. Often formal and informal systems co-exist, and sometimes 'informal' seed production becomes 'formalized' as it becomes more regulated. India, for example, indicated that the two systems operate through different, but complementary mechanisms. In its country report, Kenya acknowledged that the 'informal' seed trade, despite being illegal, was responsible for the maintenance of rare crop varieties. Uzbekistan commented similarly and Peru noted the importance of informal exchange of seed of underused crop species.

Several multinational companies have recently increased their market share through takeovers and mergers. The top five are now responsible for more than 30% of the global commercial seed market and much more for crops such as sugar beet, maize and vegetables.[32] The private sector tends to target large markets that offer high profit margins. Five of the top ten seed companies listed in the first SoW Report have ceased to exist as independent companies, and the current top company is the size of the former top six combined. Companies in several developing countries, including Philippines and Thailand, are now able to supply many of the vegetable seeds formerly supplied by American, European, and Japanese multinationals. Other countries, including Chile, Hungary, Italy and Kenya have greatly increased their certified seed production. Egypt, Japan and Jordan all mentioned their reliance on the private sector for the supply of hybrid vegetable seed. The global seed market was worth $30 billion in 1996 and is now valued in excess of $36 billion.

In developed countries, the tendency has been to encourage the private sector to produce seed, with public funding moving further upstream into research and germplasm development. In developing countries, substantial investments were made in the 80s and 90s to develop public seed production; however this proved to be very costly, resulting in donors curtailing their support and encouraging states to disengage from the sector. Some countries, such as India, consider seed production to be of strategic importance for food security and have maintained a strong public seed production system. In other countries and for crops like hybrid maize, the state has withdrawn from seed production with the private sector taking over. For crops with less market opportunities, such as self-pollinated crops, seed production systems have essentially collapsed in many countries. In spite of the overall decline in public sector involvement in the seed sector, there are indications that this situation may now be reversing in some parts of the world. In Afghanistan, Ethiopia, Jordan, Palestine, Tunisia and Yemen, country reports mentioned that community-based production and supply systems, and village-based seed enterprises have been promoted in an effort to increase the production of quality seed.

Investment by the private seed sector has mainly been targeted at the most profitable crops (hybrid cereals and vegetables), and mostly in countries with market-oriented agriculture.

Some governments, such as India, have therefore tried to find an optimal way forward, with the public sector investment focusing on areas that are of relatively little commercial interest to the private sector such as on pre-breeding and on developing varieties for resource poor farmers and crops of limited market potential.

With increasing professionalism in the ecological farming sector, there is a small but increasing demand for high quality organic seed. In spite of problems of compliance with seed certification requirements, especially regarding seed-borne diseases, seed production for organic and low-input agriculture is expanding. Lebanon, for example, indicated that it has a small organic seed market. Likewise there is a growing organic seed market in the Netherlands but there are difficulties in adapting current conventional seed legislation to cover it.

There is also an expanding market for old, 'heritage' varieties. While the USA allows marketing of local varieties without restriction, the EU has a strict seed regulatory framework, although it is currently developing mechanisms to permit the legal marketing of seed of 'conservation varieties' that do not meet normal uniformity requirements. Norway reported on seed legislation that, in harmony with EU legislation, outlaws the marketing of seed of old varieties. However, it has instituted a heritage system for historical gardens and museums. It is possible to market uncertified landrace seeds in Finland with the intention of conserving and promoting diversity, and Greece too permits the use of heritage seed in ecological farming systems. In Hungary the production of seed of old varieties and landraces is considered a priority and Jamaica and Ghana also reported interest in heritage seed programs.

Transgenic seed production has increased over the past ten years and the seed market has grown in value from $280 million in 1996 to over $7 billion in 2007,[33] when a total of 114.3 million hectares was planted with GM-crops, mainly soybean, maize, cotton and oilseed rape. The rate of increase is slowing in developed countries, but rising steadily in developing countries. Even though the number of countries where GM-crops are being tested is rising fast, the number of countries where significant acreages of GM-crops are commercially planted is limited – mainly Argentina, Brazil, Canada, China, India, South Africa and USA. GM varieties have met with strong opposition from the general public and civil society in many European and other countries in relation to concerns about their potential impact on human health and the environment. This has resulted in the prohibition or restricted adoption of this technology in many countries. However, there are signs that, in recent years, GM varieties are starting to be adopted in Africa - such as, for example, GM cotton in Burkina Faso. Philanthropic foundations are also funding the development of transgenic crops such as cassava for Africa.

The expansion of the seed trade over the last several decades has been accompanied by the development of increasingly sophisticated seed regulatory frameworks. These are generally aimed at supporting the seed sector and improving the quality of seed sold to farmers. However, in recent years, questions have been raised about many of these regulatory systems. In some cases, regulations can lead to more restricted markets and reduced cross-border trade, limit farmers' access to genetic diversity, or lead to long delays in variety release. Seed regulations can be complex and costly. There are even cases in which seed regulations outlaw 'informal' seed systems even though they are responsible for supplying most of the seed.

In recognition of these concerns, there has been an evolution in seed regulations in many countries over the last decade. Several regions, e.g. Europe, Southern Africa and West Africa have simplified procedures, facilitated cross-border trade, and harmonized seed regulatory frameworks. In many countries, however, an optimum balance still needs to be found between farmer protection and simpler procedures.

Biosafety regulatory systems have been developed in order to manage any potentially negative effects that might arise from the exchange and use of living modified organisms (LMOs), including genetically modified crop varieties. The Cartagena Protocol on Biosafety to the CBD, which entered into force in 2001, represents a new dimension to seed production and trade and underpins the current development of national biosafety regulations in many countries. In spite of concerns over the capacity of some developing countries to fully implement such regulations, it is likely that they will lead, in the near future, to a wider adoption of GM varieties. As of March 2009, the Protocol had been ratified by 156 countries.

Emergency seed aid is an area receiving increased attention in recent years. Following natural disasters and civil conflicts, local and international agencies have generally relied on direct distribution of seed to farmers to quickly restart crop production. However, recent studies have shown potentially negative side-effects of such practices including undermining the national seed sector and reducing local crop diversity. New intervention approaches based on markets (seed fairs and vouchers, for example) and on in-depth assessments of the seed security situation are increasingly being used by aid agencies in their efforts to restore agricultural production following a disaster.

Many of the country reports referred to the sub-optimal state, or even the non-functionality, of seed production and distribution systems. Bangladesh and Senegal, for example, indicated that despite considerable private sector involvement, there were serious problems related to the cost, quality and timeliness of seed delivery. Albania indicated there was a paucity of formal markets, while others, including Cuba, cited the lack of incentives and appropriate legislation. It was widely reported that certified seed production was often unreliable and could not cope adequately with demand. However, various other countries, including Germany, Slovakia and Thailand, reported having highly organized seed production and marketing systems, based on effective national legislation and cooperation between the public and private sectors.

NISM data from 44 developing countries indicated that the major constraint to seed availability involved insufficient quantities of various classes of seed (basic, commercial and registered) rather than availability and cost of seed or inadequate distribution systems.

4.9 Emerging challenges and opportunities

Since the publication of the first SoW report, several of the issues described earlier have become more significant and new ones have emerged. Globalization of economies has continued to move forward - albeit sometimes unevenly, food and energy prices have risen, organic foods have become popular and economically attractive, and the cultivation of genetically modified crops has caused heated debate. Several of these are intertwined with the wide fluctuations in food and energy prices that have impacted on both producers and consumers of agricultural products. Five such issues are discussed in the following sections. These are: sustainable agriculture and ecosystem services, new and under utilized crops, biofuel crops, health and dietary diversity and climate change.

4.9.1 Sustainable agriculture and ecosystem services

Sustainable agriculture has been defined as *agriculture that meets the needs of today without compromising the ability of future generations to meet their needs*. Whether high-input systems, reduced external inputs and/or higher input-use efficiency, sustainability takes into account due regard for conservation of natural resources (biodiversity, soils, water, energy, etc) and social equity (see Chapter 8). While promotion of sustainable agriculture is the Priority Activity Area 11 of the GPA, few country reports referred specifically to it or to the use of PGRFA to promote or protect ecosystem services, a more recently recognized feature of sustainable agriculture. However, countries did mention various aspects of crop production that have a direct bearing on biodiversity loss, soil erosion, soil salinity, water use and the mitigation of climate change.

Many of the key ecosystem services provided by biodiversity sustain agricultural productivity, e.g. nutrient cycling, carbon sequestration, pest regulation and pollination. Promoting the healthy functioning of ecosystems helps ensure the resilience of agriculture as it intensifies to meet growing demands. In the context of agricultural production, it is also crucial to understand and optimize the ecosystem goods and services provided by PGRFA and associated biodiversity (e.g. pest and disease organisms, soil biodiversity, pollinators, etc.). This is of particular importance in the face of increasing global challenges, such as feeding expanding populations and climate change. With appropriate incentives and support, farmers can enhance and/or manage ecosystem services such as providing wildlife habitats, better rain infiltration and ultimately help with clean water flows, and waste absorption.

A number of countries[34] described changes in land use that aim to encourage agricultural tourism through such activities as the development of low-input agriculture, museum plots, historical gardens, heritage and food festivals and cultural landscapes. These aim, *inter alia*, to take land out of intensive food crop production, secure the future for heritage crop varieties, maintain levels of agricultural biodiversity, reduce pollution and support education and public awareness. Several country reports[35] indicated a growing interest in organic agriculture systems that often use specific crop varieties that have been bred to perform well under low-input conditions. The Commonwealth of Dominica reported that 'The entire island is a 'green zone' where organic farming is actively being promoted and conservation measures implemented'.

Many country reports stressed the importance of breeding for resistance or tolerance to pests and diseases, salt, drought, cold and heat, both to improve yield security and reduce the need for pesticides, thereby limiting pollution and biodiversity loss. Crops that are genetically engineered for such resistances, and which are already grown in many countries,[36] under certain conditions can contribute to sustainable agriculture by helping reducing requirements for agrochemicals. However, their use is controversial and is often limited by policies and legislation in producing and/or importing countries. The cultivation of such genetic engineered crops in the centers of diversity has been an issue of heated debate.

Biodiversity loss has many causes including changes in habitat and climate, invasive species, overexploitation and pollution. Loss of agrobiodiversity can ultimately affect key ecosystem services, including soil erosion control, pest and disease regulation and maintenance of nutrient cycles. Ghana noted the effects of environmental degradation in its country report and Djibouti specifically mentioned the role of PGRFA in halting desert encroachment and helping stabilize the environment.

4.9.2 Under-utilized species

There are numerous public and private breeding programmes for the world's major crops; however there is relatively little research on, or improvement of, less-utilized crops and species harvested from the wild, even though they can be very important locally. Such crops often have important nutritional, taste and other properties, or can grow in environments where other crops fail. Initiatives such as "Crops for the Future" promote research on, and the improvement of, under-utilized crops.[37]

The development of new markets for local varieties and diversity-rich products is the subject of Priority Activity Area 14 of the GPA; however it is difficult to gauge the extent to which the objectives outlined in the Area have been accomplished. Several country reports did indicate progress in developing new, diversity-rich, products and markets for under-utilized species. Uganda, for example, has started processing, packaging and selling Vitamin A enriched sweet potato juice and an anti-fungal soap made from sweet potato leaves. Uzbekistan reported that many farmers '… continue to grow local varieties' and that the ' … distribution of (endangered) local varieties is supported.' Bolivia reported 38 under-utilized species for which various activities were taking place, but little full-scale breeding. Uruguay also cited a large number of under-utilized species that were grown in the country for food, beverages, medicines and ornamentals. There were several additional reports from the Americas detailing the use of local fruits in making jams, juices and preserves.

There appears to be considerable variation among countries with regard to their perceptions of the availability and size of local and international markets for under-utilized crops. Ghana suggested there was a lack of markets. Ecuador and Fiji both indicated that although there was an interest in commercializing local fruits, their future was predicted to be mainly in expanded local consumption. Thailand researched markets for local and diversity-rich products but concentrated on medicinal and pharmaceutical species rather than food crops. Trinidad and Tobago has developed both local and foreign niche markets and The Netherlands reported on its niche markets for underused vegetables. Benin was one of only a few countries that envisaged greatly expanded market opportunities.

According to many of the country reports there is a general lack of awareness of the importance and potential of diversity-rich and local varieties which, if addressed, would do much to encourage greater use. Cuba, for example, stated that it '… is necessary to increase public awareness regarding production of diverse and local products and increase markets for them'.

There were no reports of truly new food crops but some traditional crops were finding new uses. Cassava, for example, was being used to make biodegradable plastic in India, cocoa butter was used in making cosmetics in Ghana, and New Zealand reported new uses for certain marine algae. Many 'new' tropical fruits, vegetables and ornamentals have made their way into European markets over the past decade, giving rise to speculation that there might be opportunities for marketing many more products internationally.

An NISM survey appraised the current situation and potential for under-utilized crops in Africa, the Americas, Asia and the Near East (185 stakeholders in 37 countries). Of the more than 250 crops mentioned, fruits were considered to have a particularly high potential in three of the regions, followed by vegetables. Survey respondents reported on various initiatives underway for expanding market opportunities, including strengthening cooperation among producers, street fairs, organic farming, niche variety registration systems, initiatives in schools and product labeling schemes. Among the main constraints listed were lack of priority by local and national governments, inadequate financial support, lack of trained personnel, insufficient seed or planting material, lack of consumer demand and legal restrictions.

4.9.3 Biofuel crops

Crops for the production of biofuel were scarcely mentioned in the country reports although the Philippines reported an interest in biofuels and Zambia mentioned *Jatropha curcas*, the oil of which is a diesel substitute. This and several more traditional biofuel crops, including maize, rapeseed, sunflower, soybean, oil palm, coconut and sugarcane, were included on crop lists in several reports, but rarely with reference to their biofuel use. Since publication of the first SoW report, the merits and demerits of biofuels have been hotly debated. Concerns have been expressed over possible competition with food production and the consequent impact on food prices, as well as over possible negative environmental impacts arising from intensive biofuel production.[38] On the other hand, biofuels offer new opportunities for agriculture[39] and could make an important contribution to reducing global CO_2 emissions.

Biofuel crops for use in power stations were mentioned by Germany, and several European countries[40] and the USA[41] reported on a number of plant species that are being bred for energy production. These include willows, poplars, *Miscanthus* spp. and switchgrass. A number of countries are researching high-density algal systems to produce biodiesel and fuel alcohol,[42] although New Zealand saw no immediate useful biofuel application for its collection of freshwater algae.

4.9.4 Health and dietary diversity[43]

Plants provide the majority of nutrients in most human diets around the world. While hunger, linked to an inadequate total food intake, remains a major problem in many parts of the developing world and in some areas in developed countries, there is also growing recognition of health problems associated with inadequate food quality and the lack of specific nutrients in diets. Such problems are particularly acute among poor women and children and can be addressed both through increasing dietary diversity as well as through breeding crops – especially the major staples – for improved nutritional quality. Nonetheless, there was scant mention in country reports of breeding crops for better nutritional quality, although several mentioned the relationship between PGRFA and human health. Malawi, for example, recognized the importance of dietary diversity in relation to HIV/AIDS and Thailand saw market opportunities from linking PGRFA to the health sector. It was even reported from Africa that kola nuts were being processed to produce an appetite suppressant to help combat obesity. Kenya and several countries in West Africa confirmed a renewed interest in traditional foods, in part due to perceived nutritional advantages.

Different plants are rich in different dietary constituents, the combination of which underlies the health-promoting effects of a diverse diet. Such compounds include, for example, various antioxidants as found in many fruits, tea, soybean, etc.; fibre that can help reduce hypercholesterolemia; and sulphoraphane, an anti-cancer, anti-diabetic, and anti-microbial compound found in many *Brassica* species. Plant breeding could play a useful role in developing crops that are richer in such compounds and much more needs to be done to characterize and evaluate both cultivated and wild germplasm for nutritionally related traits. However, in many cases little is known about the relative importance of genetics, production conditions and food processing at the level and availability of specific nutrients in a given food product.

Important amino acid mutants have been identified in several crops, but have been exploited to the greatest extent in breeding maize for high lysine content (quality protein maize, QPM) and in inter-specific crossing to produce high protein NERICA rice.[44] The application of biochemistry, genetics and molecular biology to manipulating the synthesis of specific plant compounds offers a promising avenue for increasing the nutritional value of crops. Examples include:

1. Golden rice, which contains high levels of beta-carotene, the precursor of Vitamin A, through an introduced biosynthetic pathway;
2. Iron-enhanced rice containing a ferritin gene introduced from beans, plus a heat-tolerant phytase system from *Aspergillus fumigatus* to degrade phytic acid that inhibits iron absorption;
3. Numerous on-going research projects on iron, zinc, provitamin A, carotenoids, selenium and iodine.

Two major international programmes have been initiated on biofortification:[45]

1. HarvestPlus, a programme of the CGIAR that targets the nutritional improvement of a wide variety of crop plants through breeding and focuses on the enhancement of beta-carotine, iron and zinc;[46]
2. The Grand Challenges in Global Health Initiative, targeting banana, cassava, sorghum and rice, mostly through genetic modification.[47]

Since the publication of the first SoW report it has become increasingly recognized that improved quality diets can help people survive certain medical conditions and can prevent the occurrence of others. Sufferers from HIV/AIDS, for example, can live healthier and more productive lives when they are better nourished. Uganda, in its country report, stated that "the increased emphasis on the value of nutrition in treatment of HIV/AIDS patients has drawn attention to local herbs and … 'diversity rich' products'. While some PGRFA can also have direct medical benefits through specific pharmaceutical properties - a fact that was mentioned in several country reports - none mentioned the breeding of crops for pharmaceutical production.

4.9.5 Climate change[48,49]

Some of the poorer, food-insecure countries are particularly vulnerable to the effects of climate change on crop production, and there will be significant risks to wild biodiversity, including crop wild relatives. These changes will result in a growing demand for germplasm that is adapted to the new conditions, seed systems will need to be strengthened and international policy will need to facilitate greater access to PGRFA.

The country reports made relatively minor reference to the impact of climate change. However, together with rapidly growing and changing demands for greater production, these changes are likely to result in increased pressure to cultivate marginal land. Africa is the most vulnerable continent. Small islands often have high levels of threatened endemic species and are also particularly vulnerable to rises in the sea level. It has been suggested that maize will probably be eliminated from southern Africa by 2050 and groundnut, millet and rapeseed productivity will drop in South Asia.[50]

The range and migration patterns of pests and pathogens is likely to change, biocontrol agents will be affected and synchronization of pollinators and flowering may be disrupted. Although switching to new cultivars and crops has the potential to alleviate many of the expected disturbances, this will require a greatly increased access to genetic diversity and a substantial strengthening of plant breeding efforts. Breeding must take into account the environment predicted for the crop's target area 10 to 20 years hence, requiring that prediction methods be further developed so as to be as reliable as possible. Certain under-utilized crops are likely to assume greater importance as some of the current staples become displaced. It will be very important to characterize and evaluate as wide a range of germplasm as possible for avoidance, resistance or tolerance to major stresses such as drought, heat, water-logging and soil salinity. Research is also needed to gain a better understanding of the physiological mechanisms, biochemical pathways and genetic systems involved in such traits. But having the basic programmes with adequate human and financial resources to screen germplasm and to run variety trials in key agroecologies is of paramount importance.

4.9.6 Cultural aspects of PGRFA

The use of PGRFA represents a broad continuum of activities that runs across the cultural, ecological, agricultural and research landscapes. Among these, agricultural uses of PGRFA get by far the most attention, although other uses are also extremely important in certain situations and to certain communities. Local and traditional foods, for example, are of great importance to almost all cultures; an importance that goes well beyond their nutritional significance. They might have important ceremonial or religious associations and in many cases are important to a society's identity. However, traditional cultural uses tend to change slowly over time and are unlikely to have changed substantially since the first SoW report was published. But having the basic programmes with adequate human and financial resources to screen germplasm and to run variety trials in key agroecologies is of paramount importance. But having the basic programmes with adequate human and financial resources to screen germplasm and to run variety trials in key agroecologies is of paramount importance. This dimension was well documented for potation most developing countries as part of the 'international year of potato'.[51]

4.10 Changes since the first SoW report was published

The country reports indicated that during the period between the first and the second SoW reports there have been increased efforts to improve the state of use of plant genetic resources. Some of the most important changes since the first SoW report are:

- Overall global plant breeding capacity has not changed significantly; a modest increase in the number of plant breeders has been reported by certain national programmes and a decline by others;
- There has been little change in the crop focus of the breeding programmes as well as in the principal traits sought by plant breeders. Major crops still receive the most attention and yield per unit area continues to be the primary trait sought. However, recently more attention has been paid to underused crops and to the use of crop wild relatives;
- The number of accessions and a number of countries characterized and evaluated has increased in all regions, and many countries use molecular markers to characterize their germplasm;
- Progress has been made in genetic enhancement and base broadening with several countries reporting the use of these techniques as a way to introduce new traits from non-adapted populations and wild relatives;
- While country reports from all five regions indicated an increase in farmer participation in plant breeding activities over the past decade, farmers' involvement is still largely limited to priority setting and selecting from among advanced lines or finished varieties;
- The constraints (human resources, funding and facilities) to greater use of PGRFA and their relative importance are similar to that reported in the first SoW report. However, issues such as the lack of fully effective linkages between researchers, breeders, curators, seed producers and farmers, and lack of comprehensive information systems were also highlighted this time;
- Since the publication of the first SoW report several new challenges have been recognized and these are beginning to be addressed in national analysis and strategies. The ones highlighted in this report include: sustainable agriculture and ecosystem services, new and underused crops, biofuel crops, health and dietary diversity, and climate change;
- The area sown to transgenic crops, and hence transgenic seed production, has increased substantially since 1996 and the seed market has grown in value. In 2007, 114.3 million hectares were planted to GM-crops, mainly soybean, maize, cotton and oilseed rape;

- There has been a major increase in the international seed trade, which is dominated by fewer and larger multinational seed companies than in 1996. The focus of interest of these companies remains primarily on the major for which farmers replace seed yearly;
- Investment by the public sector in seed production, already at a low level in most developed countries at the time of first SoW report, has since then also decreased significantly in many developing countries. In many countries access to improved varieties and quality seed is limited, especially by non-commercial farmers and the producers of minor crops;
- There is a trend to harmonize seed regulations at the regional level (Europe, Southern Africa and West Africa) in order to facilitate seed trading and foster the development of the seed sector;
- There has been an increasing move to integrate local seed systems within emergency responses aimed at supporting farmers in the aftermath of natural disasters and civil conflicts;
- There is a growing market for specialized 'niche' seeds, such as for 'heritage' varieties.

4.11 Gaps and needs

While good progress has been made in several aspects relating to the use of plant genetic resources since the first SoW report was published, the country reports still recognize a number of gaps and needs. These include:

- The need for greater awareness among policy makers, donors and the general public of the value of PGRFA, and their essential role in crop improvement, in meeting such global challenges as ensuring food security and mitigating and adapting to climate change;
- There is a need for countries to adopt appropriate and effective strategies, policies and legal frameworks and regulations that promote the use of PGRFA, including appropriate seed legislation;
- Considerable opportunities exist for strengthening cooperation among those involved in the conservation and sustainable use of PGRFA, at all stages of the seed and food chain. Stronger links are needed, especially between plant breeders and those involved in the seed system, as well as between the public and private sectors;
- There is an urgent need to increase plant breeding capacity worldwide, especially in countries where there has been a decrease in capacity over the last decade. The training of more scientists, technicians and field workers, and the provision of better facilities and adequate funds are all required;
- Greater efforts are needed in order to mainstream new biotechnological and other tools within plant breeding programmes;
- More investment is needed in the improvement of under-utilized crops as well as of traits in major crops that are likely to assume greater importance in the future as increased attention is paid to health and dietary concerns and as the effects of climate change intensify;
- In order to capture the potential market value of native crops, local varieties, under-utilized crops and the like, there is a need for greater integration of the efforts of individuals and institutions having a stake in different parts of the production chain, from the development and testing of new varieties, through value added activities, to the opening up of new markets;

- A lack of adequate characterization and evaluation data and the capacity to generate and manage it, remain a serious constraint to the use of many germplasm collections, especially of under-utilized crops and wild relatives;
- Greater attention is needed in the development of core collections and other collection subsets, as well as in pre-breeding and base broadening efforts, as effective ways to promote and enhance the use of PGRFA;
- In order to promote and strengthen the utilization of participatory breeding approaches countries have to revise their policies and legislation, including the development of appropriate varietal maintenance schemes and seed certification procedures for further multiplication of such varieties; it is also necessary to focus on capacity building aspects and to ensure the integration of this methodology in the national breeding strategies;
- Greater efforts are needed to encourage and support entrepreneurs and small-scale enterprises concerned with the sustainable use of PGRFA.

Box 4.1 Examples of initiatives and legal instruments developed to promote PGRFA use

- The African Centre for Crop Improvement (ACCI),[52] established in 2004 by the University of KwaZulu-Natal, trains plant breeders from eastern and southern Africa in conventional and biotechnological methods, with a focus on crops that are important for food security of the poor. ACCI has a network of 47 plant breeders and co-supervisors in 13 countries. A parallel programme, the West African Centre for Crop Improvement (WACCI),[53] was set up by the University of Ghana to improve the crops that feed the people of West Africa;

- Other national initiatives have been launched to halt the decline of public investment in plant breeding, including a scheme in the USA coordinated through a taskforce of the Plant Breeding Coordinating Committee;[54]

- The Generation Challenge Programme (GCP)[55] is an initiative of the CGIAR that aims to create improved crops for small farmers through partnerships among research organizations. It focuses on using biotechnology to counter the effects of drought, pests, diseases and low fertility of soil through sub-programmes on genetic diversity, genomics, breeding, bioinformatics and capacity building; and

- The GIPB[56] is a multi-stakeholder partnership of public and private sector parties from developing and developed counties. It aims to enhance the plant breeding capacity and seed delivery systems of developing countries and improve agricultural production through the sustainable use of PGRFA. It is an internet-based initiative facilitated by FAO, and provides a major portal for information dissemination and sharing.

Box 4.2 Improvement of passion fruit (*Passiflora* spp) using genetic resources from wild relatives[a]

It is estimated that the genus *Passiflora* includes some 465 species, approximately 200 of which originated from Brazil. In addition to their medicinal and ornamental properties, some 70 species bear edible fruit. In order for this enormous range in genetic diversity to be used in breeding programs, either interspecific crossing among species or the direct transfer of genes through recombinant DNA technology are needed. Research at the Embrapa Cerrados station has resulted in several fertile inter-specific hybrids with a potential application in plant breeding. For example, types have been obtained that combine commercial traits with disease resistance.

Wild species can contribute to the improvement of cultivated passion fruit in many different ways. Work underway in Brazil has shown that:

- A number of interspecific hybrids, e.g. with *P. nítida,* can be used as rootstocks due to their strong stems;
- Wild relatives can be used to develop cultivated forms with resistance to bacteriosis, virosis and Cowpea Aphid-Borne Mosaic Virus (CABMV). Wild species with resistance to anthracnose have also been noted;
- A number of wild species of *Passiflora* are fully self-compatible, a trait that is potentially important where Africanized bees are a problem, or labour for manual pollination is expensive. Other wild species, e.g. *P. odontophylla*, have a flower structure that facilitates pollination by insects that otherwise fail to pollinate the flowers;
- Wild species, such as *P. setacea* and *P. coccinea* could contribute daylength insensitivity which, under the conditions of the Centre South region of Brazil, would enable production to occur all year round;
- *P. caerulea* and *P. incarnata* both have tolerance to cold, a potentially important trait for several growing regions in Brazil;
- Several wild species also have the potential to improve the physical, chemical or taste characteristics of fruit for the fresh market or the pulp for sweets or ice-cream, e.g. larger fruit size from *P nitida* and purple colouration from *P. edulis;*
- Interspecific crossing has also resulted in several new ornamental types.

a. Information taken from the country report of Brazil

[1] Some countries interpreted the term *core collection* as the main collection existent for a given crop and reported on it – see country reports from Egypt, Indonesia and Romania
[2] Country report Brazil, China, Malaysia and Russian Federation
[3] Country report Chile, Lebanon, Pakistan and Thailand
[4] http://www.procisur.org.uy/online/regensur/documentos/libro_colecciones_nucleo1.pdf
[5] http://www.figstraitmine.org/index.php?dpage=11
[6] Global Partnership Initiative for Plant Breeding Capacity Building www.km.gao.org/gipb
[7] http://km.fao.org/gipb/pbbc/
[8] Guimaraes, E.P., Kueneman, E. and Paganini, M. (2008) Assessment of the national plant breeding and associated biotechnology capacity around the world. International Plant Breeders Symposium.
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[10] Murphy, D. (2007) Plant breeding and biotechnology. Societal context and the future of agriculture. Chapter 9, Decline of the public sector. Cambridge University Press
[11] Communication with national consultants responsible for GIPB surveys.
[12] www.cuke.hort.ncsu.edu
[13] The State of the World's Plant Genetic Resources for Food and Agriculture (1998), FAO, Rome.
[14] Sonnino, A., Carena, M.J., Guimaraes, E.P., Baumung, R., Pilling, D. and Rischkowsky, B. (2007) An assessment of the use of molecular markers in developing countries. FAO, Rome.
[15] Country briefs GIPB found at http://km.fao.org/gipb/pbbc/
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[17] www.isaaa.org (accessed January 2009).
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[20] FAOSTAT (http://faostat.fao.org/site/567/default.aspx#ancor)
[21] http://www.globalrust.org/
[22] The country report of the Philippines is an example
[23] The country report of Tanzania is an example
[24] The country report of Portugal is an example
[25] Almekinders, C. & Hardon, J. (Eds) 2006. Bringing Farmers Back Into Breeding: Experiences with Participatory Plant Breeding and Challenges for Institutionalisation. Agromisa Special 5, Agromisa, Wageningen. pp 140.
[26] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:162:0013:0019:EN:PDF
[27] Fulton, M. (2008) Consultant's report on The State of the Art of Methodologies, rechnologies and capacities for Crop Improvement and Base Broadening - A contribution to the 2nd State of the World's Plant Genetic Resources for Food and Agriculture
[28] Murphy, D. (2007) Plant breeding and biotechnology. Societal context and the future of agriculture. Cambridge University Press.
[29] PBBC database and for example the country report of Tajikistan
[30] Country report of Portugal
[31] Information from the Near East regional synthesis
[32] Louwaars, N. (2008) Consultant's report on Seed Systems and PGRFA – A contribution to the 2nd State of the World's Plant Genetic Resources for Food and Agriculture.
[33] Louwaars, loc. cit.
[34] Including Finland, Ghana, Greece, Lebanon, Norway and Jamaica
[35] Including Greece, the Netherlands, Poland, Portugal and the Philippines
[36] www.isaaa.org
[37] Crops for the Future was launched in 2008 following the merger of the Global Facilitation Unit for Underutilized Species and the International Centre for Underutilized Crops.
http://www.cropsforthefuture.org/
[38] Bourne, J.K. loc.cit
[39] Bourne, J.K. (2007) Biofuels. National Geographic, October 2007, 212: 38-59.
[40] www.rothamsted.ac.uk
[41] www.usda.gov
[42] Bourne, J.K. loc. cit.

[43] Several items of information in this section were reported in a consultant's report (2008) The contribution of plant genetic resources to health and dietary diversity.

[44] NERICA: the New Rice for Africa – a Compendium (2008) page 118-119

[45] Consultant's report (2008), The contribution of plant genetic resources to health and dietary diversity

[46] www.harvestplus.org

[47] www.gcgh.org

[48] Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P. and Naylor, R. (2008) Prioritizing climate change adaptation needs for food security in 2030. Science 319: 607-319.

[49] Much of this information derives from a consultant's report, Jarvis, A., Upadhyaya, H., Gowda, C.L.L., Aggerwal, P.K. and Fujisaka, S. (2008), Climate change and its effect on conservation and use of plant genetic resources for food and agriculture and associated biodiversity for food security.

[50] Lobell, D.B. et al. (2008) Prioritizing climate change adaptation needs for food security in 2030. Science 319: 607-610. plus the Climate Change consultant's report.

[51] http://www.potato2008.org/

[52] www.acci.org.za

[53] www.wacci.edu.gh

[54] http://cuke.hort.ncsu.edu/gpb/

[55] http://www.generationcp.org/

[56] www.km.gao.org/gipb

Chapter 5

The state of national programmes, training needs and legislation

5.1 Introduction

National programmes for the conservation and sustainable use of plant genetic resources for food and agriculture aim to support economic and social development and underpin efforts to develop more productive, efficient and sustainable agricultural systems. They lie at the heart of the global system for conserving and using PGRFA. While international cooperation between national programmes is essential, and is dealt with in Chapter 6, this chapter attempts to define and categorize national programmes, describes developments that have taken place since 1996, identifies current needs and opportunities for training and capacity building, and describes the status of national legislation. The chapter concludes with a summary of the main changes that have taken place since the publication of the first SoW report and presents key gaps and needs for the future.

5.2 State of national programmes

5.2.1 Purpose and functions of national programmes

Priority Activity Area 15 of the GPA advocates the formation or strengthening of national programmes for PGRFA as a strategy for involving and coordinating all relevant institutions and organizations in a country, in a holistic enterprise aimed at promoting and supporting the conservation, development and use of PGRFA. Countries vary in the extent to which national PGRFA programmes are incorporated in national developmental plans, or are included in more specific agricultural or environmental policies and strategies. Components of a national programme include both the institutions and organizations involved in PGRFA as well as the linkages and communications among them. In practice, the design and function of a national programme is country specific, shaped by many factors such as history, geography, the status of biodiversity, the status of agricultural production and relationships with neighbouring countries with respect to shared biodiversity.

An efficient national PGRFA programme should have well-defined goals, clear priorities and a blueprint for implementation. It needs to be well structured and coordinated, involving all relevant stakeholders, no matter how diverse. Its success depends to a large extent on the commitment of national governments to provide the necessary funding, policies and institutional framework.

Given the above, it is not surprising that there is considerable heterogeneity among national programmes in terms of their goals, functions, organization and infrastructure. At the same time there are many commonalities, in part arising from obligations incurred under various international agreements such as the CBD, the ITPGRFA, the Global Plan of Action for the Conservation and Sustainable Utilization of PGRFA (GPA), and various other trade and intellectual property rights agreements (see Chapter 7).

5.2.2 Types of national programmes

In the first SoW report, an attempt was made to classify the diversity of national programmes into three categories: (i) a formal, centralized system, (ii) a formal, sectorial system in which different institutions take on a leadership role for specific components of the national programme, with national coordination, and (iii) a national mechanism for coordination only, involving all relevant institutions and organizations. In retrospect, this scheme may have been too simplistic.

The process of compiling information for the second SoW report revealed a wide diversity of national PGRFA systems, in terms of size, structure, organization, institutional composition, funding and objectives. It was difficult to distinguish the three categories of national PGRFA activities used for the first SoW report. For example, there are centralized systems that may not be 'formal' and there are sectorial systems that do not have coordination mechanisms.

Perhaps the most familiar model is a national centralized system based on a vertical integration of PGRFA units within a national institution, such as a Ministry of Agriculture, funded by the national government, with linkages to relevant sectors outside the central organization, such as academic institutions, NGOs and the private sector, coordinated by a national advisory, coordinating committee. Another model is a national system based on decentralized but strongly coordinated sectorial leadership, with funding arising independently from each sector. Yet another model might be a regional structure involving other countries, balancing components that are missing in one country with components that are well developed in another. Expertise and germplasm are shared, training opportunities are enhanced, and greater efficiency is achieved as a result of no single country having to develop every component independently.

Countries were not asked to self-identify the type of national programme that existed in their country with respect to the three categories, for either the first or second SoW reports. In many instances, factors that would have helped in the categorization were not reported. Information on the current status and trends in national programmes since the first SoW report was published should thus be interpreted with caution. Interpretation is complicated further by the fact that a different and smaller set of countries provided information now compared to those reporting in 1996, and that in most cases a different person or group of people was responsible for providing country report information in the two time periods. In spite of these difficulties, some revealing and relevant comparisons are possible.

5.2.3 Status of development of national programmes

There has been considerable progress over the last decade in the percentage of countries having a national programme of one type or another. Of the 109 countries[1] that contributed information for both the first and second SoW reports, 43% reported having no national programmes in 1996, whereas 96% report having some form of national programme now.

At the time of the first SoW report, 10% of reporting countries had a national programme 'under development'. Of these, seven provided information for this second SoW report and all but one had followed through, now being able to report a national programme in place.

Of the 118 countries[2] for which information was provided for the second SoW report either through a country report, an NISM, or participation in a regional workshop, the most common type of national programme reported is a sectorial type (67% of reporting countries), whether formal or informal, with national coordination or not.

Most of the current reports from countries that still lack a national programme recognize the value of establishing one and discuss what form it might take and what is needed. A few of these indicated that committees are currently looking into the situation.

It is clear that there is still room for countries to improve national systems and coordination over PGRFA. Comprehensive PGRFA management requires the integration of efforts within and outside the country concerned, involving the participation of a diverse set of institutions. As described elsewhere in this report (see, for example, Chapter 4.7.3), the weak links between the PGRFA conservation and use sectors is still a major concern. There are some signs that the situation may be improving, for example, a number of countries now include their PGRFA programmes within the context of their national development plans and the like. However, strong and fully effective institutional links between national genebanks and plant breeders and/or farmers are still comparatively rare, especially in developing countries.

Even in countries with active and well-coordinated national programmes, certain key elements may be missing. National, publicly accessible databases, for example, are still comparatively rare as are coordinated systems for safety duplication and collaborative public awareness.

Another area that still requires greater attention in many national programmes (see also Chapters 1 and 4) is a more effective integration of the efforts of the public and private sectors. In a number of countries, private plant breeding and seed sector companies need to see the value of devoting time and resources to strengthening their collaboration with public sector technical institutions. In other cases, however, it was the private sector that insisted that governments should establish national programmes.

A valuable tool for establishing and improving national programmes was mentioned in many country reports: the NISM on the Implementation of the GPA.[3] NISMs are recognized by participating countries for their valuable role in facilitating information management and the exchange of PGRFA, as well as for fostering within-country identification of stakeholders, and promoting collaboration.

The process of contributing to an NISM integrates the efforts of different stakeholders in national genetic resources activities, thus helping to build a broader institutional base for the conservation and use of PGRFA. NISMs provide a key platform for information sharing, policy setting, scientific exchange, technology transfer, research collaboration, and for the determination and sharing of responsibilities.

5.2.4 National programme funding

The majority of the country reports indicated that the primary source of funding to sustain their national programme was from the national government. This is one indicator that can be used to help define a ‘formal’ programme. In some cases this is supplemented by funds from international donors. Individual components of the national system (e.g. units involved with conservation, crop improvement, seed systems, crop protection, protected areas, extension, education, or training) generally receive finance from a variety of different sources: different ministries, national or international funding agencies and foundations, or private philanthropy. To a large extent the participation of private, for-profit companies within national systems is self-funded.

Although several countries, especially in Europe, reported that overall funding has increased substantially since 1996, many of the country reports noted that their national programme received inadequate and unreliable funding, making it difficult to plan over multiple years. While national genebanks *per se* generally have direct and identifiable funds provided by the national government, the financing of national coordinating mechanisms and other elements of a national system are often buried within other budget items and hence subject to greater uncertainty.

In some regions - for example, Africa - the country reports have highlighted the need for greater support for infrastructure. Where this has not been forthcoming from national governments, international and regional organizations, bilateral agencies, and private foundations have sometimes been able to help. In general, funding support from such agencies for the conservation and use of PGRFA in developing countries appears to have increased since the time of the first SoW report.

Although there are no figures available to indicate overall trends in funding, the CBD, GPA and ITPGRFA have all clearly helped to give greater prominence to the subject – and overall this has almost certainly had a positive impact. Likewise, the international publicity surrounding events such as the launching of the Global Crop Diversity Trust and the opening of the SGSV have served to raise awareness of conserving and using PGRFA in the minds of the general public, policymakers, and donors.

While the level and reliability of funding are major factors that determine the strength and effectiveness of a national PGRFA programme, other factors are also important such as the extent of public awareness and support, political will, and the quality of leadership and management. These factors clearly vary from country to country and from region to region, as does financial support.

5.2.5 Role of the private sector, NGOs, and educational institutions

As described above, in most countries the national government is the principal entity involved in national programmes for the conservation and use of PGRFA, generally through multiple public sector institutions under one or several ministries. However, the involvement of other stakeholders appears to have expanded since the publication of the first SoW report. These include private, for-profit companies, NGOs, farmer organizations and other rural community groups, and educational institutions, especially universities.

Private sector

Private-sector companies are very diverse in size, scope, and core business and their participation in national programmes reflects this diversity. Their interests and involvement vary from the collecting and maintenance of germplasm collections (generally breeders' working collections) and the evaluation of germplasm, to genetic improvement, multi-location testing, biosafety, seed release, multiplication, and distribution. They are also sometimes actively involved in education, training, and public awareness activities. Over recent years, public-private research and development partnerships appear to have grown in importance, especially in the area of biotechnology[4]. Within Western Europe, USA, Australia and other industrialized countries, the private sector now accounts for a large proportion of the total breeding effort (see Chapter 4) and it is expanding rapidly elsewhere, especially in parts of Latin America and Asia. Stronger links between private companies and public institutions involved in basic research, conservation, genetic enhancement, information systems, and the like offer considerable potential benefits for all parties concerned.

NGOs and the informal sector

In many countries NGOs play a very important role at the farm and community level in promoting and supporting the conservation and management of PGRFA. Their activities range from direct involvement in *in situ* conservation in protected areas to promoting the on-farm management of PGRFA for the benefit of local households and communities. Many are also active in lobbying governments to devote more attention to these issues. In a number of countries, NGOs actively participate in nationally coordinated efforts. It is not possible to provide a comprehensive overview or analysis of NGO activities in PGRFA because they are so numerous and diverse, especially at the regional and national levels.

According to the country reports, NGOs are active in most regions, and are particularly strong in Africa, Asia, Europe, and parts of Latin America. Both Germany and the Netherlands reported the effective involvement of NGOs and in Asia NGOs such as LI-BIRD in Nepal, and the M.S. Swaminathan Research Foundation and Gene Campaign in India have been very active in promoting the on-farm management of PGRFA. Farmers' unions and cooperatives are recognized as important and crucial stakeholders in many countries of the Near East region. A number of national PGR workshops and training programmes have helped enhance the role of NGOs within national programmes, especially in technology transfer, public awareness, and capacity building.

Universities
Universities are active participants and collaborators in national PGRFA programmes in many counties and in all regions. Many examples have been cited elsewhere in this report. Not only are universities vital for their role in the development of human resources but they also contribute substantially to research and development of PGRFA. They have become increasingly involved in the application of biotechnology to conservation and crop improvement, for example, in cryopreservation, *in vitro* propagation, the development and application of molecular markers, the measurement and monitoring of genetic diversity and the analyses species relationships.

While they play a vital role, many universities and other institutions of learning, especially in developing countries, lack adequate facilities and financial support, which limits their ability to contribute to their maximum capacity.

5.3 Training and education

Meeting national programme needs for training and capacity building is among the Priority Activity Areas listed in the GPA. Strengthening staff competence is needed in all sectors: scientists and technicians, development workers, NGOs and farmers. There is also a need for special efforts to be made to educate research managers and policy makers in policy and legal matters.

Since 1996, a number of developments have taken place in training and education, with significant new opportunities opening up in several countries. Collaboration in training between national programmes and international and regional organizations, especially with FAO and the CGIAR Centres, has expanded and capacity building opportunities have increased. Much of this has been the result of additional funding becoming available from bilateral and multilateral donors, for research projects that have a human resources development component. More universities are now offering short-term informal courses as well as longer-term M.Sc. and Ph.D. courses. New training materials are becoming available and field and laboratory facilities for training have improved in a number of countries. However, in spite of these developments, there is a still a need for greater capacity in education and training to meet the expanding demand for new, well-trained professionals and for upgrading the skills and expertise of those already engaged in the conservation or use of PGRFA.

Most national programmes concerned with on-farm management of PGRFA aim to build both their own professional capacity as well as that of the farmers with whom they work. However, many NGOs and development agencies lack sufficient qualified personnel to impart the necessary training to farming communities. While higher degree training on *in situ* conservation and on-farm management of PGRFA was specifically mentioned by Indonesia, Malawi and Zambia, most capacity building in these areas has been less formal. Cuba, India and Nepal, for example, all indicated that there has been an increase in the number of groups trained in participatory plant breeding (see Chapter 4) and the compilation of community biodiversity registers. Several country reports[5] mentioned activities on the on-farm management of PGRFA that include technical courses for farmers, farmer-to-farmer training, the setting up of farmer associations, courses for extension workers and short-term professional training. Participatory approaches have been central to much of the work undertaken in this area and have resulted in the enhancement of local capacity for informal research and the evaluation of diversity.

In Morocco and Nepal, work on diversity has been linked to literacy campaigns that *inter alia* help strengthen diversity management capabilities. Increased gender awareness has been another important facet within many projects, not only through the collection of gender-disaggregated data and the participation of women farmers, but also through increased involvement of women in research and project management.

Since the first SoW report, many new manuals and other tools have been developed to support training on how to manage on-farm genetic diversity. Examples include a training guide developed by Bioversity International,[6] a source book on conservation and sustainable use of agricultural biodiversity by CIP,[7] and a 'tool kit' to help with the development of strategies for the on-farm management of PGRFA.[8] The community biodiversity management approach, including community biodiversity registries, aims to build the capacity of local communities to make their own decisions on the conservation and use of biodiversity.[9] It does this through facilitating community access to knowledge, information and genetic materials.

The following sections summarize major developments in relation to training and education on a regional basis.

Africa
From an analysis of the country reports it appears that in spite of advances in several countries, overall capacity to carry out training and education on PGRFA in Africa remains somewhat limited. Universities in Benin, Ghana, Kenya and Madagascar all reported that courses on genetic resources have been included in university curricula at both the under-graduate and post-graduate level. In Benin and Côte d'Ivoire, post-graduate courses have been initiated in collaboration with Bioversity International, and a partnership has been established in Kenya to teach a diploma course on PGR conservation involving Maseno University together with The Kenya Agricultural Research Institute (KARI), the Kenya Forest Research Institute (KEFRI) and the National Museums of Kenya (NMK). In Ethiopia, the Institute of Biodiversity Conservation (IBC) organises both long-term and short-term training courses on the management of genetic resources.

Americas
In Latin America, several countries have invested in educational programmes. Bolivia, for example, has offered 10 short-term University courses in plant genetic resources since 1996 and in Brazil, the Federal University of Santa Catarina started M.Sc. and Ph.D. courses in 1997 with financial support from the National Council for Scientific and Technological Development (CNPq). In Argentina, undergraduate and M.Sc. courses are available in several universities. In Costa Rica, the EARTH University offers regular courses in subjects related to genetic resources and in 2002, a post-graduate course, entitled 'Management and Sustainable Use of Plant Genetic Resources', was conducted at CATIE with the aim of improving the use of genetic diversity of cultivated plants. A large training programme exists in Mexico, where many universities and other institutions offer courses in aspects of genetic resources, from secondary school to post-graduate levels, and in Uruguay, undergraduate courses in applied science cover subjects related to conservation and sustainable use of biological diversity. According to the country reports, however, there is currently no formal training programme in genetic resources in Cuba, Dominican Republic, Ecuador, Jamaica, Peru, Trinidad and Tobago or Venezuela.

Asia and the Pacific
In recent years several regional and international short-term training courses have been conducted including the following: field genebank maintenance (UPM, Malaysia); *in vitro* conservation and cryopreservation (NBPGR, India); documentation and bamboo genetic resources (FRIM and UM, Malaysia); *in vitro* conservation and cryopreservation of tropical fruit genetic resources (NBPGR, India); molecular data analysis of tropical fruit tree species diversity (Huazhong Agricultural University, China); cryopreservation of tropical fruit genetic resources (Griffith University, Australia); use of molecular markers for characterization of genetic resources (Huazhong Agricultural University, China); and on-farm and community-based conservation and the role of public awareness (SPC, Fiji).

Both Bioversity International and JIRCAS/JICA have been actively involved in training on the management of PGRFA in the region. Recently Biodiversity International has recognized NBPGR, India and the Chinese Academy of Agricultural Sciences (CAAS)-Bioversity Centre of Excellence for Agrobiodiversity Resources and Development (CEARD) in China as Centres of Excellence for training on *in vitro* conservation and cryopreservation. In Nepal, LIBIRD and NARC have been identified as Centres of Excellence for training in on-farm conservation.

The University of Philippines Open University (UPOU) has entered into an agreement with Bioversity International to develop specialized courses on international and national policy and laws relating to the management of plant genetic resources. The Genetic Resources Policy Initiative (GPRI) of Biodiversity International has published several useful training documents and other materials for use in education and training programmes.

Since 1996, the NBPGR and the IARI in New Delhi have offered joint MSc. and Ph.D. degree programmes in the conservation and management of genetic resources. Formal degree programmes have also been initiated at UPLB, Philippines in 1997 and in Malaysia and Sri Lanka in 2000.

In the Pacific Islands, the University of the South Pacific (USP), Alafua Campus, Samoa, hosted a meeting on PGR Education in 2004. Later, the Centre for Flexible and Distance Learning of USP was mandated to develop a course curriculum on genetic resources.

Europe
In Europe, many universities provide courses in agricultural sciences, plant breeding, and plant science, which include aspects of plant genetic resources. Formal B.Sc., M.Sc. and Ph.D. degree programmes having a special emphasis on biodiversity and genetic resources have been established in several countries as a response to calls for action by the CBD. In some countries, genebank staff are engaged as university faculty members on an adjunct or part-time basis, and various institutions, societies, NGOs, and a few national genebanks offer short courses (workshops, seminars) on practical aspects of PGRFA. Courses on collecting and conservation techniques are very much in demand, especially in Eastern Europe.

Near East
Universities in Morocco, Egypt and Jordan are developing Master's degree programs that focus on the conservation of genetic resources and the management of natural resources.
Substantial efforts have been made in a number of countries to increase public awareness on the importance of conserving biodiversity in general and agro-biodiversity in particular. Syria, Jordan, Palestine, Morocco and Kazakhstan have developed educational curricula and extra-curricular activities directed at increasing the awareness of students and their parents. A variety of different media (TV, radio, workshops, meetings, posters, leaflets, agricultural fairs and ecotourism) have been used by government agencies and by different biodiversity projects in the region to help educate the public. The innovative use of rural

theatre by the Extension Directorate in Syria, for example, has resulted in increased general public awareness of the role and value of PGRFA.

In conclusion, while good progress has been made, there is still much to be done to provide more and better training opportunities at the local, national, regional, and international levels.

5.4 National policy and legislation

While many important agreements relating to PGRFA have been negotiated and adopted at the international level (see Chapter 7), the number of national laws and regulations has also increased. Annex 5.1 provides details of the status of countries with respect to their signing or ratifying major international agreements as well as the enactment of national laws and regulations relating to the conservation and use of PGRFA. The following sections describe the status of national regulations and legislation in five areas: phytosanitary regulations, seed regulations, intellectual property rights, farmers' rights, and biosafety. Regional approaches to phytosanitary regulations are dealt with in Chapter 6.4 and the topic of access and benefit-sharing is a major topic of Chapter 7.

5.4.1 Phytosanitary regulations

Most countries in all regions have adopted national phytosanitary legislation. Since the first SoW report was published, much of the new national legislation in this area has been influenced by the adoption in 1997 of the revised text of the IPPC (see Chapter 6.4).[10] Many countries subsequently amended their plant protection laws or enacted new ones to ensure that their legislation used the new definitions from the 1997 text of the IPPC and reflected the concepts and rules of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures. One of the main changes that occurred is the requirement that the decision to import plants, plant products, and other regulated articles should have a scientific basis. All decisions on imports that are not based on international standards must be based on pest risk analysis.

5.4.2 Seed regulations

The seed system is highly regulated in most countries, from the release of new varieties and the quality control of seeds to the legal status of organizations that implement certification and release procedures. Since the first SoW report was published, three main trends have occurred: the emergence of voluntary rules on seed certification and variety release; the growing use of accreditation principles alongside official national rules and standards; and the regional harmonization of seed laws (see also Chapter 4.8).

The expansion of the private seed sector has led many countries to review their seed laws, resulting in many cases in a shift from compulsory rules on seed certification and variety release towards more voluntary arrangements. This has occurred mainly in developed countries such as Australia, Canada and New Zealand but also in some Latin American, African and Asian countries. Such a shift aims to avoid a situation in which strict rules implemented by government agencies constrain seed commercialization. The largely self-regulated nature of variety release and seed certification in the USA allows for the marketing of seeds of local varieties. In India, changes have been made in the other direction - from voluntary to more compulsory rules, with a view to strengthening the protection of consumers and small farmers.

The growth of the private seed sector has also led to an increased use of accreditation principles in various industrialised countries and those with emerging economies. These generally operate alongside official, compulsory national rules and standards to which seed producers must adhere. The introduction of private certification and testing services or in-company systems, complements or, in some cases, replaces the government's traditional role in these matters. Recognizing this, in 2000, the International Seed Federation (ISF) updated a whole set of its rules dealing with contracts among seed merchants and between companies and contract growers.

The third main trend is the regional harmonisation of seed laws, especially in Africa and Europe, in order to avoid disincentives to cross-border seed trade. The most far-reaching example of regional harmonization of seed laws is in the European Union, following the establishment of a joint variety list in 2002[11] and the adoption, over several decades, of uniform certification methods and seed quality standards.[12] In 2008, the concept of 'conservation varieties' was introduced. These are varieties that do not have to adhere to such strict uniformity and stability rules.[13] However, this opening is strictly limited to old and locally used varieties.

In the countries of Southern Africa, the harmonisation of seed laws with the assistance of FAO has resulted in a joint variety list that enables varieties to be grown in the different member countries. However, a variety must be listed in at least two countries before it enters the Southern African Development Community (SADC) regional list. Harmonisation efforts are also growing in Western Africa (members of the Economic Community of West African States, ECOWAS), with the development of a joint variety list and the adoption in 2008 of Regulation C/REG.4/05/2008 on the Harmonization of the Rules Governing Quality Control, Certification and Marketing of Plant Seeds and Seedlings in the ECOWAS Region.

In parallel with these three main trends, and despite the growing awareness of the value of informal exchange of seeds among farmers, most laws explicitly apply to packed and certified seed with only very few countries having exemptions or special arrangements for farmers' seed (see Box 5.1). Most seed laws basically protect the seed label and are reserved for controlled seeds, which are labelled as 'Government-certified seeds' as in Korea or 'Government-tested seeds' as in Botswana. The Moroccan seed law restricts the use of the word 'seed' to controlled seeds only. In many countries, the informal marketing of local varieties and landraces is officially illegal.

A major challenge in developing national seed laws is balancing the need to promote diversity and local varieties with systems that promote access to good quality seed of appropriate varieties. Another challenge reported by several countries is how to ensure the effective implementation of seed laws and regulations in situations where government funding, trained staff and infrastructure are limited.

5.4.3 Intellectual property rights

Systems for protecting and rewarding intellectual property in relation to PGRFA primarily involve plant breeders' rights and patents. Trade secrets have a place, e.g. in the maintenance of inbred lines for producing hybrid varieties, and other intellectual property rights (IPR) systems such as copyright may also have a role to play, e.g. in relation to databases and other information sources. Some of the issues in play at the nexus between the conservation and use of PGRFA are free exchange versus restricted access, and PGRFA as a national or international, private or public good. The following sections give an overview of the state of play at the national level in each of these areas of intellectual property protection.

Plant breeders' rights
Plant breeders' rights allow breeders the exclusive right to sell seed of their varieties over a given number of years, but these varieties can still be used without restriction for research

and breeding ('breeders' exemption'). The number of countries that provide legal protection to plant varieties through plant breeders' rights (PBR) has increased substantially over the past 10 years. While most western European countries, the USA and Canada already had PBR systems in place prior to the publication of the first SoW report, many countries in other regions have introduced PBR legislation since then. Of the 85 countries that recognize plant breeders' rights in Africa, Asia, Eastern Europe, Near East, and Latin America and the Caribbean, 60 have done so in the last decade and seven others are currently drafting legislation.

This trend is largely attributable to an increased adherence to the TRIPS Agreement that requires countries to provide for the protection of plant varieties 'either by patents or by an effective *sui generis* system or by any combination thereof' (article 27.3). Among the *sui generis* models, the PBR models provided by the Convention for the Protection of New Varieties of Plants are widely considered to meet the requirements of TRIPS, and the number of countries that have joined the Convention's governing body, the International Union for the Protection of new Varieties of Plants (UPOV), almost doubled between 1998 and 2007, reaching 65 in January 2009.

The increasing membership of UPOV is also a consequence of the increasing number of free trade agreements that have been concluded recently and that extend standards of intellectual property protection beyond the TRIPS requirements, for instance, by making explicit reference to UPOV. In contrast, there is no reference to UPOV in the TRIPS Agreement itself and countries can choose any 'effective *sui generis* system' they wish.

In Africa, nine countries[14] have implemented plant breeders' rights legislation, three of which have done so in the last decade. Six others[15] are all in the process of developing or approving such regulations.

In Asia and the Pacific, 14 countries[16] have implemented plant breeders' rights, 11 of these did so in the last decade. Nepal is currently drafting a bill on PBR.

In the Americas, 21[17] of the 34 countries in Latin America and the Caribbean have plant breeders' rights legislation in place and two others, Guatemala and St. Vincent and the Grenadines, have developed draft legislation. In all countries except Argentina, Chile, Colombia, Cuba and Paraguay, the legislation has been adopted since the publication of the first SoW report.

All European countries have put in place legislation on plant breeders' rights except Andorra, Bosnia and Herzegovina, Iceland, Lichtenstein, Monaco, Montenegro and San Marino. While most Western European countries adopted such legislation before 1996, many amendments to the original laws and regulations have been made over the past decade. Eastern European countries have mostly been involved more recently, with more than half of them having enacted laws in the last decade.

Twenty-one of the 30 countries in the Near East region have adopted plant breeders' rights,[18] the large majority having done so in the last decade. The CIS countries adopted an agreement on the legal protection of plant varieties in 2001 that aims to foster cooperation in that field, including in the examination process.

Many countries that are not UPOV members have designed their own PBR laws modelled on the text of the 1978 Act. This is particularly the case for countries in Asia (e.g., India and Philippines), and some in Africa and Latin America. One reason for this is because of concerns over the 1991 Act that states that while farmers may be allowed to reproduce seed for their own use (farmers' privilege), this should take into account 'the legitimate interest of the breeder' and, furthermore, it allows farmers to share, exchange or sell seed only by exemption. In this regard, some countries have recently introduced the farmers' privilege into their PBR legislation, such as Uruguay in 2009.

Patents

When the first SoW report was under preparation, the issue of patenting varieties or parts of varieties (e.g. genes or traits) and biotechnological processes (e.g. transformation) had only recently begun to emerge. Since then it has become the subject of much debate, especially as a result of increased adherence to the TRIPS Agreement that requires signatory countries to provide for the patenting of micro-organisms and genetically engineered organisms ('non-biological and microbiological processes'). While parties are allowed to exclude from patentability plants and animals 'and essentially biological processes for the production of plants and animals', they must provide either patents or an 'effective *sui generis* system' or both, for plant varieties. Patents are generally claimed not for a single variety, as is the case with PBR, but for a whole class of varieties or even a whole species; e.g. all those having a patented trait or that were developed using a patented process. And unlike PBR, the patent system includes neither a breeder's exemption nor a farmer's privilege, although it can include a limited research exemption.

Today relatively few countries allow patent protection for new crop varieties. However, the patent system is widely used in the USA, at least in part because of concerns that the UPOV 'farmers' privilege' results in insufficient protection. Australia and Japan also offer forms of patent protection for new crop varieties. In Japan, for example, the novelty requirement for patentability is interpreted in such a way that varieties that show breakthrough improvements can be protected with a patent, whereas others can only be protected by PBR.

In 1998, the European Union adopted Directive 98/44/EC on *the Legal Protection of Biotechnological Inventions* that allows patents to be awarded for a wide range of biotechnological materials and processes, including products containing or consisting of genetic information. The Directive provides for certain exemptions, in particular the farmers' exemption allowing small-scale farmers to freely use products harvested from specified plant varieties for propagation or multiplication on their own farm. Similarly, some European countries, notably France and Germany, have introduced an explicit breeder's exemption into their national patent system.

Whereas several emerging countries such as China and India have recently amended their patent laws to comply with TRIPS requirements and, in particular, to make microorganisms patentable, most developing countries, especially in Africa, consider that life forms cannot be patented and that plant varieties should be protected through *sui generis* systems. Patents on plants are not allowed in Latin American countries.

One recent trend in patent protection in relation to PGRFA has been the increasing number of free trade agreements that promote higher standards of intellectual property protection than required in the TRIPS Agreement.

5.4.4 Farmers' rights

While the issue of farmers' rights was a topic of extensive discussion prior to the publication of the first SoW report, it has since become even more hotly debated, particularly around the time of the final negotiations of the ITPGRFA (see Chapter 7). The importance of farmers as custodians and developers of genetic diversity for food and agriculture was recognized in the ITPGRFA through the provisions of Article 9 on Farmers' Rights. Such rights are seen to include: the protection of traditional knowledge relevant to PGRFA; the right of farmers to equitably share benefits that result from their use; their right to participate in making decisions at the national level on matters related to the conservation and sustainable use of PGRFA; and the right of farmers to save, use, exchange and sell farm-saved seed/propagating material, subject to national law. Although farmers' rights do not deal with the protection of intellectual property *per se*, they are often regarded as a counterpart to it and countries that have enacted legislation promoting such rights have done so within their plant breeders' rights laws.

The state of national implementation of farmers' rights is the focus of a recent study by the Fridtjof Nansen Institute in Norway[19]. The study describes examples of projects or activities that have resulted in substantial achievements in each of the areas referred to in the previous paragraph. Some of these involve national legislation; others focus more on civil society initiatives. Examples of such initiatives include the movement to resist increasing the scope of breeders' rights in Norway and the creation of a registry of rice varieties maintained at the community level in Philippines, as a way of protecting traditional knowledge and farmers' varieties against misappropriation.

Eight countries have adopted regulations covering one or more aspects of farmers' rights and a few others are currently drafting legislation in this area. Before the concept was formally adopted in the ITPGRFA, Bangladesh, India and Thailand had implemented legislation that protected farmers' rights in terms of the right to save, use, exchange, and sell farm-saved seed on a noncommercial basis, participate in making decisions and, in the case of India, introduced a 'gene fund' to support farmers who maintain genetic resources (see Box 5.2).
Ethiopia is the only African country to have adopted a law on farmers' rights[20] although Ghana, Malawi and Namibia are currently developing draft laws.

In the Americas, of the Latin American and the Caribbean countries, only Costa Rica has addressed the issue of farmers' rights, establishing a Small Farmers Board in 1998 as a member of the National Commission for the Management of Biodiversity, which has the function of formulating national policies on the conservation and sustainable use of biodiversity.

In Asia and the Pacific, in addition to Bangladesh, India and Thailand, Malaysia has enacted farmers' rights legislation, and Nepal and Philippines are currently developing draft farmers' rights laws. In Malaysia, the Protection of New Plant Varieties Act of 2004 seeks to introduce more flexibility into the requirements for the registration of farmers' varieties. While reiterating the normal criteria for professionally bred varieties, i.e. that they must be new, distinct, uniform, and stable, the Act exempts new varieties bred or discovered and developed by farmers, local communities, and indigenous people, from the requirements of stability and uniformity; farmers' varieties must be distinct and identifiable. The intention of the legislators is to facilitate claims by farmers for new, distinct, and identifiable varieties that are vegetatively/clonally propagated. The Act also restricts the scope of breeders' rights by excluding from protection acts that are carried out privately on a non-commercial basis, thus allowing small farmers to continue their normal practices of using and exchanging farm-saved seed.

In the Near East, no country has yet enacted legislation on farmers' rights,[21] although Turkey is currently developing such a law and Pakistan has drafted legislation on access to biological resources and community rights.

In industrialized countries, where farmers' organizations are usually well connected to policy processes, the issue of farmers' rights has not taken on much importance and the debate on the use of farm-saved seed is held in the framework of IPR and seed legislation. In Europe, while only Italy and Spain have adopted regulations on farmers' rights, a number of countries are considering how they might support the implementation of farmers' rights in developing countries.

5.4.5 Biosafety

Biosafety has been defined as the 'the avoidance of risk to human health and safety, and to the conservation of the environment, as a result of the use for research and commerce of infectious or genetically modified organisms.'[22] Concerns over biosafety have grown substantially over the last decade, in parallel with the expanding use of LMOs and the impact of infectious agents. Factors that have contributed to this increasing concern have included outbreaks of transboundary diseases affecting animals, plants and people; heightened awareness of the potential impact of LMOs on biological diversity; increased concern over general food safety issues; and greater attention to the impact of agriculture on environmental sustainability.

Since the first SoW report, biosafety has emerged as an important issue, and many countries in all regions have now either adopted national biosafety regulations or frameworks, or are currently developing them. At the international level, the adoption of the Cartagena Protocol on Biosafety of the CBD[23] in 2000 marked a milestone in cooperation on the safe transfer, handling and use of LMOs. The Cartagena Protocol entered into force in 2001, and as of March 2009, had been ratified by 156 countries. It now provides the international legal framework that underpins the current development of national biosafety regulations in many countries. In spite of concerns over the capacity of some developing countries to fully implement such regulations, it is likely that they will lead, in the near future, to a wider adoption of genetically modified varieties.

Over the past decade many countries have adopted national regulations and biosafety frameworks that aim to reduce risks to the environment and human health. The USA has adopted an incremental approach to the regulation of biotechnology, based on the regulation of the characteristics of a product, rather than on the assumption that products of biotechnology automatically need special regulations. In Europe, on the other hand, pressure from society has resulted in the introduction of an approach based on an interpretation of the 'precautionary principle' that can block use of an LMO until evidence is presented that the transgenic organism is safe. This has led to only very limited approvals of LMOs for commercial use. At the EU level, the *Directive 2001/18/EC on the release of GMOs* was adopted in 2001. At the national level, 24 of the 27 EU countries have enacted biosafety or biotechnology-related laws and among non-EU European countries, six[24] have done so as well. Albania, Armenia, Croatia and Georgia are currently drafting biosafety legislation.

The development and adoption of biosafety frameworks and regulations in developing countries is increasing rapidly, supported in many cases by foreign donors or regional intergovernmental agencies. Many African countries[25] have adopted formal biosafety measures while 33 other African countries[26] are in the process of developing or adopting such regulations. In the Americas, all Central and South American countries have adopted some form of regulation or guidelines on biosafety, with the exception of Ecuador and Nicaragua, and these are both currently drafting such regulations. Of the island nations, only Cuba has enacted biosafety laws, although in 12 other countries[27], legislation is being formulated.

In Asia and the Pacific, legislation or guidelines on biosafety are in place in ten countries[28] and draft regulations are under development in 18,[29] while in the Near East, only Kazakhstan, Pakistan and Tajikistan have adopted biosafety legislation and it is under development in 13 other countries.[30]

5.5 Changes since the first SoW report was published

While it has been patchy, progress has been made overall since the publication of the first SoW report in the strengthening of national programmes, the development of training capacity and, particularly, in the adoption of national policies, laws, and regulations relevant to the conservation and use of PGRFA. Nevertheless, as indicated above, there is still a way to go in each of these areas.

- Although the first SoW report classified national programmes into three categories, since then it has become clear that such a typology is too simplistic and that there is huge heterogeneity among national programmes in terms of their goals, functions, organization and structure;
- There has been considerable progress in establishing national programmes, at least in part as a consequence of the adoption of the ITPGRFA and GPA. Of the 109 countries that provided information for both the first and second SoW reports, 43% had no national programme in 1996 whereas 96% now have one;
- Even in countries with active and well-coordinated national programmes, certain elements are still often missing. National, publicly accessible databases, for example are still comparatively rare as are coordinated systems for safety duplication and collaborative public awareness;
- The new NISM on the Implementation of the GPA was mentioned by many country reports as a valuable tool for establishing and improving national programmes;
- Although several countries, especially in Europe, reported that overall funding has increased since 1996, many of the country reports noted that their national programme received inadequate and unreliable funding, making it difficult to plan over multiple years;
- While in most countries national government institutions are the principal entities involved in national programmes, the inclusion of other stakeholders has expanded, especially of private for-profit companies, NGOs, farmer organizations and educational institutions;
- Public-private research and development partnerships appear to have grown in importance, especially in plant breeding and biotechnology, not only in developed but also in many developing countries;
- Universities have become increasingly involved in research on PGRFA, especially in the application of biotechnology to conservation and crop improvement;
- New education and training opportunities have opened up in several countries and more universities now offer M.Sc. and Ph.D courses. Collaboration in training between national programmes and international and regional organizations has become stronger and new training materials have been developed;
- Since the first SoW report was published, most countries have enacted new national phytosanitary legislation, or revised old legislation, in large part in response to the adoption in 1997 of the revised International Plant Protection Convention;
- There have been three main trends in national seed legislation over the past decade: the emergence of voluntary rules on seed certification and variety release; the growing use of accreditation principles alongside official national rules and standards; and the regional harmonization of seed laws;
- Of the 85 developing and Eastern European countries that now recognize PBR, 60 have done so in the last decade. Seven others are drafting legislation;

- The importance of farmers as custodians and developers of genetic diversity was recognized in the ITPGRFA through the provisions of Article 9 on Farmers' Rights. Eight countries have adopted regulations covering one or more aspects of farmers' rights;
- Since the first SoW report, biosafety has emerged as an important issue, and many countries have now either adopted national biosafety regulations or frameworks, or are currently developing them. As of March 2009, 156 countries had ratified the Cartagena Protocol on Biosafety.

5.6 Gaps and needs

Key gaps and needs for the future include:

- Whether a national PGRFA programme is centralized, sectorial, or even regional, it is vital that there be effective coordination and collaboration among its elements, including ministries, government institutions, universities, private companies, NGOs, farmers' groups and others;
- The links between institutions concerned primarily with the conservation of PGRFA and those concerned primarily with its use are weak or even absent in many countries;
- Many countries lack nationally endorsed strategies and plans for the conservation and use of PGRFA. These are important for setting priorities, distributing roles and responsibilities and allocating resources;
- Almost half of the countries' reports indicated that they had no national information sharing mechanism (NISM) for PGRFA, and thus lack an effective tool for promoting both internal as well as international collaboration;
- There is a need to assess human resource capacity and needs in the various aspects of conserving and using PGRFA, and to use this as the basis for drawing up national (and ultimately regional and global) education and training strategies;
- In spite of the expansion of education and training opportunities over the past decade, they remain inadequate overall. More opportunities are needed both for the training of young researchers and development workers, and for upgrading the knowledge and skills of existing staff;
- Special efforts are needed in many countries to educate senior managers and policy makers about the complex legal and policy issues relating to the conservation, exchange, and use of PGRFA;
- Efforts to raise additional resources to support work on PGRFA require new and innovative approaches, better coordination in fundraising among the different institutions and sectors, and greater efforts to increase awareness among policymakers and donors as to the actual and potential value of PGRFA;
- Greater efforts are needed in many countries to develop appropriate national policies relating to the conservation, exchange and use of PGRFA, to address the concerns of all stakeholders and to ensure that all legislation is non-conflicting and complementary.

Box 5.1 Examples of developments in national legislation that support the conservation and use of traditional crop varieties

Bangladesh: The forthcoming national framework for PGRFA is expected to include, *inter alia,* the recognition of Farmers' Rights, including provisions for benefit sharing.

Ecuador: The new national constitution approved in September 2007 strongly promotes the conservation of agricultural biodiversity and the right of people to choose their own food. In particular, article 281.6 has the title: 'Promote the preservation and rehabilitation of agro biodiversity linked to ancestral knowledge; likewise its use, conservation and free seed exchange'. Several Government programmes will be put in place to support small and medium farmers in the production of organic and traditional food.

Morocco: In 2008 a law was adopted covering Appellation of Origin, Geographical Indication and Agricultural Labelling of produce. It allows for the registration of products from local varieties and landraces and thus helps promote their use and conservation.

Nepal: A 2004 amendment of the 'Seed Regulatory Act' has added a new provision on plant variety registration that allows for the inclusion of farmers' field trial data and other data from participatory trials, in registration applications. This will enable farmers' varieties and landraces to be registered, thus helping to promote conservation; and it will also expand opportunities for the sharing of any benefits that result from any increased use of local genetic resources.

Tunisia: In 2008 a law was adopted to promote the *in-situ* and *ex-situ* conservation of date palm genetic resources. It includes the use of *in vitro* methods to multiply varieties for conservation purposes and to rehabilitate old plantations in the oases.

Box 5.2 India – Protection of Plant Varieties and Farmers' Rights Act of 2001

The 2001 Act protects the rights of farmers to save, use, sow, re-sow, exchange, share, and sell their farm produce, including seed, of a variety protected by breeders' rights, provided that they do not sell branded seed packaged and labeled as a seed variety protected under the Act.

The Act provides for the registration of farmers' varieties on a par with breeders' varieties. Farmers' varieties are required to meet the same criteria of distinctiveness, uniformity, and stability, but are not required to meet the criterion of novelty. It also protects the rights of farmers by requiring breeders and other persons applying for the registration of varieties under the Act to declare that the genetic material acquired for developing the new variety has been lawfully acquired and to disclose any use of genetic material conserved by tribal or rural families in the development of the registered variety. Claims for compensation may be made where it is found that the tribal or rural communities have contributed material used in the development of the variety. The Act provides for claims for benefit sharing to be made after the publication of certificates of registration of new varieties. Where benefit sharing is ordered by the responsible governmental authority, the money is to be paid into the National Gene Fund. Farmers who conserve or improve landraces or wild relatives of economic plants are eligible to receive an award from the Gene Fund.

[1] It includes the 106 countries that presented complete reports and three countries that provided information through a short questionnaire.

[2] The Near East, and the Latin American and the Caribbean regional consultations allowed gathering information from countries that did not present their country reports, respond to the short questionnaire or have the National Information Sharing Mechanism.

[3] http://www.pgrfa.org/selectcountry.jspx

[4] For example in Australia, Brazil, China, India, Philippines, Thailand and USA

[5] For example Cyprus, the Dominican Republic, Ethiopia, Germany, Jamaica, Jordon, Tanzania and Thailand

[6] Jarvis, D.I., Myer, L., Klemick, H., Guarino, L., Smale, M., Brown, A.H.D., Sadiki, M., Sthapit, B., Hodgkin, T. 2000. A training guide for in situ conservation on-farm: version 1. IPGRI, Rome Italy.

[7] CIP-UPWARD. 2003. Conservation and sustainable use of agricultural biodiversity. A sourcebook. International Potato Center (CIP), Regional Office for East, Southeast Asia and the Pacific (ESEAP), Bogor, Indonesia.

[8] Smale, M. 2006. Valuing crop biodiversity: On-farm genetic resources and economic change. International Food Policy Research Institute, Washington DC USA and IIPGRI. Rome Italy.

[9] Country Reports India, Nepal, Uganda

[10] https://www.ippc.int/IPP/En/default.jsp

[11] Council Directive 2002/53/EC of 13 June 2002 on the common catalogue of varieties of agricultural plant species

[12] For example Council Directive 2002/57/EC of 13 June 2002 on the marketing of seed of oil and fibre plants; Council Directive 66/402/EEC of 14 June 1966 on the marketing of cereal seed; Council Directive 66/401/EEC of 14 June 1966 on the marketing of fodder plant seed

[13]Commission Directive 2008/62/EC on 20 June 2008 on conservation varieties

[14] Burkina Faso, Cameroon, Côte d'Ivoire, Kenya, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe

[15] Ethiopia, Ghana, Malawi, Mauritius, Namibia and Uganda

[16] Australia, Bangladesh, China, India, Indonesia, Japan, Rep. of Korea, Malaysia, New Zealand, Philippines, Singapore, Sri Lanka, Thailand and Vietnam

[17] Argentina, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay and Venezuela as reported in 'Latin American and the Caribbean (LAC) Region Synthesis' 2009.

[18] Algeria, Azerbaijan, Bahrain, Cyprus, Egypt, Iran, Iraq, Israel, Jordan, Kazakhstan, Kyrgyzstan, Malta, Morocco, Oman, Pakistan, Saudi Arabia, Tajikistan, Tunisia, Turkey, Uzbekistan and Yemen as reported in 'Near East and North Africa Regional Analysis of Plant Genetic Resources for Food and Agriculture' 2008.

[19] Andersen and Winge 2008, op. cit.

[20] Proclamation on 'Access to Genetic Resources and Community knowledge and Community Rights Proclamation No. 482/2006'

[21] The Near East Regional Analysis of Plant Genetic Resources for Food and Agriculture, November 2008.

[22] FAO Glossary of of Biotechnology for Food and Agriculture;
http://www.fao.org/BIOTECH/index_glossary.asp

[23] http://www.cbd.int/biosafety/

[24] Belarus, Moldova, Norway, Russia, Serbia and Switzerland

[25] Including Benin, Burkina Faso, Cameroon, Kenya, Malawi, Mauritius, Namibia, South Africa, Tanzania, Uganda, Zambia and Zimbabwe

[26] Botswana, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Dem. Rep. of Congo, Rep. of Congo, Côte d'Ivoire, Djibouti, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Mali, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Sudan, Swaziland and Togo.

[27] Antigua and Barbuda, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Guyana, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines and Suriname

[28] Australia, China, Japan, India, Indonesia, Republic of Korea, Malaysia, Nepal, New Zealand, Philippines and Vietnam

[29] Bangladesh, Bhutan, Cambodia, Cook Islands, Democratic People's Republic of Korea, Mongolia, Myanmar, Niue, Palau, Papua New Guinea, Samoa, Sri Lanka, Thailand, Tonga and Vanuatu

[30] Algeria, Egypt, Iran, Jordan, Kyrgyzstan, Lebanon, Libyan Arab Republic, Morocco, Qatar, Syrian Arab Republic, Turkey and Yemen

Chapter 6

The state of regional and international collaboration

6.1 Introduction

The previous chapter of this report described the current status of national programmes and trends that have occurred since the first SoW report was published. This chapter will describe and attempt to analyze developments at the international level.

Overall there has been a dramatic increase in international activities since 1996, in all fields related to the conservation and use of PGRFA. Many new regional and crop-specific networks and programmes have been set up, at least in part in response to the priorities for action contained in the GPA. The CBD and the IITPGRFA have both also served to give prominence to the need for greater international collaboration. Many programmes set up to promote various aspects of the Convention or Treaty, involve collaboration among multiple partners. For example, the creation of the multilateral system for access and benefit sharing under the ITPGRFA has greatly strengthened awareness of needs and opportunities in this area, and although it is not yet possible to assess its impact quantitatively, there are signs that cooperation is expanding with respect to germplasm exchange.

Chapter 1.4 describes the extent of interdependence among all nations with respect to PGRFA. Such interdependence, arising from the spread of crops around the globe from their centres of origin, makes international cooperation not just desirable but essential if the full value of PGRFA is to be realized. Awareness among policy makers and the general public of the importance of PGRFA and the extent of interdependence has grown considerably in recent years, at least in part because of high-profile initiatives such as the establishment and opening of the SGSV.

Given the very large number of regional and international networks, programmes, institutions and other cooperative initiatives involving PGRFA that are now in existence, it is not possible to mention them all and this chapter does not attempt to provide a comprehensive coverage. Indeed, given the huge diversity in types of collaborative arrangements, it is even difficult to classify them into any consistent and useful typology. This chapter thus presents major developments that have occurred since the first SoW report was published, with respect to multi-crop associations and networks, crop-specific networks, thematic networks, regional and international organizations and programmes, bilateral programmes, international and regional agreements and funding mechanisms. While an attempt has been made throughout the chapter to assess the extent of progress since 1996, this is made difficult by the fact that the information in the first SoW report is all of a qualitative nature and it has not been possible to get any quantitative data on the current status of regional and international cooperation or on trends over recent years. The chapter concludes with a review of major changes that have occurred since 1996 and lists some on-going gaps and needs for the future.

6.2 PGRFA networks

A very large number of networks are currently in existence addressing one or more aspects of PGRFA. Many of these have come into existence since the first SoW report was published. While all aim to promote and support collaboration among partners for a common purpose, there is a huge diversity in their objectives, size, focus, geographic coverage, membership, structure, organization, governance, funding, etc. For ease of reference, the term 'network' will generally be used to describe such collaborative arrangements, irrespective of whether they are formally called a network, or have adopted a different title such as association, alliance, cooperative, consortium or coalition.

Networks are very important for promoting cooperation, sharing knowledge, information and ideas, exchanging germplasm, and for carrying out joint research and other activities. They support the sharing of expertise and help compensate or provide backstopping in cases where certain of the network participants lack the critical mass to carry out particular activities. They enable synergies to be captured when different partners have different and complementary skills and capacities. Collaboration is also critical to gaining maximum benefits under legal and policy instruments such as the CBD, GPA and ITPGRFA and to meeting associated obligations.

Networks in the PGRFA field generally fall into one of three broad categories:
a) Those that focus on conservation, and these are often regional and multi-crop in nature;
b) Those that focus on one of a few specific crops and may be either regional or global in scope. The primary objective of many such networks is to facilitate crop improvement;
c) Those that address a particular topic or theme relating to PGFRA, across crops, such as seed systems, genomics, taxonomy, or *in situ* conservation.

Overall, good progress has been made since the first SoW report was published in all three groups of networks. The following sections do not attempt to provide comprehensive coverage or description of all relevant networks, but rather give a snapshot of some of the more significant changes that have occurred since 1996.

6.2.1 Regional multi-crop PGRFA networks

Since 1996, the number of regional and sub-regional PGRFA networks has grown so that all countries in all areas of the world are now eligible to join one or more of them. They bring together the heads of national genetic resources programmes, genebank managers and others concerned with conservation, and in many cases also include various users of PGRFA, such as plant breeders, NGOs and the private sector. In many cases these networks are linked to the regional fora, which in turn are key participants in the Global Forum on Agricultural Research (GFAR), described later. Table 6.1 lists the main PGRFA networks that fall in this category. Some of the major developments that have taken place over recent years in these networks, as well as a few other regional multi-crop networks, are described for each region. Overall, the networks have tended to be most active in the areas of training and documentation, and have taken on a leadership role in the development of regional PGRFA conservation strategies, under an initiative of the Global Crop Diversity Trust.

Africa

Networking in PGRFA has expanded considerably in Africa since the publication of the first SoW report. The Forum for Agricultural Research in Africa (FARA)[1] was created in 2002 as an umbrella organization bringing together and supporting the three African sub-regional associations concerned with agricultural research for development: the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the West and Central African Council for Agricultural Research and Development (CORAF/WECARD), and the Southern African Development Community - Food, Agriculture and Natural Resources Directorate (SADC-FANR). These three entities provide the umbrella for the three main PGRFA networks in Sub-Saharan Africa: EAPGREN, GRENEWECA and SADC-PGRN:

- The East African Plant Genetic Resources Network (EAPGREN):[2] EAPGREN, hosted by ASARECA, became operational in 2003 with a membership comprising ten countries.[3] The Nordic Genebank (NGB) and Bioversity International provide technical backstopping. It has undertaken a wide range of activities in eastern Africa including the exchange of information, training, awareness raising and policy advocacy. An information and documentation centre is currently being set up and greater collaboration among genebanks, farmers and other end-users is being promoted. A regional strategy for PGR has been developed under the GCDT initiative and key *ex situ* collections have been identified that require urgent regeneration as mentioned in the Ethiopia, Kenya and Uganda country reports.

- Genetic Resources Network for West and Central Africa (GRENEWECA): This network was established in 1998 under the West and Central African Council for Agriculture (CORAF/WECARD)[4]. Various meetings have been held including one in Ouagadougou, Burkina Faso, in 2006 to discuss regional strategies. Funding support has mainly come from Bioversity International and GCDT but overall GRENEWECA has not had the same level of external funding support as the other African regional PGRFA networks. The establishment of four nodal centres of excellence has been proposed as a means of strengthening PGR activities at the sub-regional level.

- SADC Plant Genetic Resources Network (SADC-PGRN):[5] Although established in 1989, the SADC-PGRN has continued to grow since the publication of the first SoW report. Its membership has risen to 14 countries and the SADC Plant Genetic Resources Centre (SPGRC), which now comes under the responsibility SADC-FANR, provides coordination. Major activities over the past decade have included the further development of the central base collection, capacity building in member countries, and the development of a documentation and information system on the *ex situ* holdings of member countries. It has also established several working groups, and a regional conservation strategy, developed under the GCDT initiative, has been published.

Americas

The Inter-American Institute for Cooperation on Agriculture (IICA) has established a system of sub-regional networks to promote collaboration in agricultural research and technology development throughout the Americas. Currently these are: PROCIANDINO (Andes), PROCICARIBE (Caribbean), PROCINORTE (North America), PROCISUR (Southern Cone), PROCITROPICOS (Amazonian tropics) and SICTA (Central America). They provide an umbrella for the six sub-regional networks on PGRFA described below and listed in table 6.1: REDARFIT, CAPGERNET, NORGEN, REGENSUR, TOPIGEN and REMERFI respectively. While many of these PGRFA networks were established prior to the publication of the first SoW report, recent years have seen relatively little major progress due to resource constraints as pointed out in the Costa Rica country report. However, new networks were established for the Caribbean (CAPGERNET) in 1998 and for North America (NORGEN) in 1999. An important development at the regional level has been the creation of the Regional Forum for Agricultural Research and Technology Development (FORAGRO):[6] Established in 1997, FORAGRO has a secretariat housed at IICA in Costa Rica. It serves all countries of the Americas and seeks to promote dialogue and cooperation in agricultural research. Its membership includes the PROCIs as well as representatives from NARS, NGOs, the private sector and others. PGRFA is an important thematic area of FORAGRO, which played a lead role in developing the PGRFA conservation strategy for the Americas under the GCDT initiative.

- The Andean Network on Plant Genetic Resources (REDARFIT):[7] The Andean network involves five countries[8] and operates under the aegis of PROCIANDINO. Major activities carried out since the first SoW report was published have included (i) workshops on PGRFA management; (ii) training courses on cherimoya, GIS and characterization, risk management and germplasm enhancement; (iii) a symposium on genetic resources in the Americas; (iv) collaborative research projects on tree tomatoes, cherimoya, native potatoes and *Lycopersicon* spp.; and (v) a programme on germplasm regeneration.

- Mesoamerican Network on Plant Genetic Resources (REMERFI): This network of eight countries[9] in Central America has been relatively inactive since 1996 although activities carried out in recent years have included: (i) training and capacity building on documentation; (ii) research projects on seeds; (iii) genetic resources of *Annonaceae* and *Sapotaceae;* and (iv) the conservation and use of native neo-tropical crops and their wild relatives.

- The Caribbean Plant Genetic Resources Network (CAPGERNET): Established in 1998, CAPGERNET consists of 28 Caribbean countries and receives technical support from CARDI, IICA, CTA and Bioversity International. Activities have included capacity building, preparing PGRFA inventories, developing an information system and germplasm exchange. It held a workshop in May 2007 in Trinidad as an input to the regional PGRFA conservation strategy. It is also coordinating the regeneration of collections of beans in Cuba, cassava in Guyana, yams in Guadeloupe, and sweet potato in Trinidad and Tobago.

- The Plant Genetic Resources Network for North America (NORGEN): Operating under the aegis of PROCINORTE, Canada, Mexico and the USA are focusing collectively through NORGEN on information exchange, training and implementing research projects in collaboration with other networks. NORGEN has provided support to several developing countries to enable scientists and technicians to participate in meetings and training courses in North America.

- The Plant Genetic Resources Network for the Southern Cone (REGENSUR): This network, comprising six countries,[10] is a network of PROCISUR that seeks to strengthen the work of the national programmes in the Southern Cone. Over the last decade, its activities have included: (i) training on germplasm enhancement, documentation, genebank management, *in situ* conservation, and seed-pathology; (ii) hosting a workshop to develop the regional PGRFA conservation strategy for the Americas; and (iii) carrying out collaborative research on maize, wheat and vegetables.

- The Amazonian Network for Plant Genetic Resources (TROPIGEN): Operating under PROCITROPICUS, this network has eight member countries.[11] Activities since 1996 have included: characterization of underexploited vegetable and fruit crops; germplasm evaluation; identifying gaps in collections; prioritizing species for PGR research and management; developing a policy framework for access and benefit sharing; information exchange, and strengthening links between genebanks and breeding programmes. It has a major focus on capacity building.

Asia and the Pacific

Almost all of the sub-regional networks in the Asia and the Pacific region concerned with PGRFA have been initiated and/or are being facilitated by Bioversity International, in collaboration with FAO and the main regional association for agricultural research, the Asia-Pacific Association of Agricultural Research Institutions (APAARI).[12] The latter has also been active in its own right in supporting activities on PGRFA and has published a regional report on PGR-related activities in 2000, provided a neutral platform for discussion of policy related issues, and endorsed the regional PGRFA conservation strategy for Asia under the GCDT initiative.

Although most of the sub-regional PGRFA networks were established prior to the publication of the first SoW report, some - particularly SANPGR - have made very substantial progress in recent years and a new network has been established for the Pacific.

- The Pacific Agricultural Plant Genetic Resources Network (PAPGREN):[13] Established in 2001, PAPGREN comprises 13 nations[14] and is coordinated by the Land Resources Division of the Secretariat of the Pacific Community (SPC), Suva, Fiji in collaboration with Bioversity International. In addition to convening a number of key meetings and workshops, major accomplishments have included: (i) developing a directory of PGR collections; (ii) drawing up a regional conservation strategy; (iii) providing advice on policy issues; (iv) supporting emergency collecting and characterization; (v) public awareness activities; and (vi) developing a web site and blog.

- Regional Cooperation in South East Asia for PGR (RECSEA-PGR):[15] Established in 1993, RECSEA-PGR has remained active in the period following the publication of the first SoW report, although activities have tended to be somewhat curtailed in recent years due to a lack of funding as Malaysia and Thailand indicate in their country report. The network, which comprises seven member countries,[16] aims to build and enhance national research capacity in South East Asia through collaboration in areas such as policy, database development and sharing information and expertise. RECSEA-PGR's major recent accomplishments have included inputs to the South, South East and East Asia (SSEEA) regional conservation strategy under the GCDT initiative and the setting up of a PGR Policy Forum together with APAARI, aimed at drafting a Standard Material Transfer Agreement applicable to all materials of common interest that are not included within Annex 1 of the ITPGRFA.

- Regional Network for Conservation and Use of Plant Genetic Resources in East Asia (EA-PGR):[17] EA-PGR promotes collaboration among its five member countries[18] in collecting, conservation, exchange, documentation/information and training. Major accomplishments since the first SoW report was published have included: (i) establishing the CAAS China-Bioversity Centre of Excellence for training on *in vitro* conservation, cryopreservation and molecular characterization; (ii) developing a sub-regional strategy as part of the overall SSEEA regional conservation strategy; (iii) joint collecting, characterization and evaluation of millets in Mongolia and DPR Korea; (iv) joint studies on genetic diversity of adzuki bean, Job's tears and perilla in China, Japan, and the Republic of Korea; and (v) establishing a network website.

- South Asia Network on Plant Genetic Resources (SANPGR):[19] Accomplishments of this six-country[20] network over the past decade have included: (i) training on seed genebank management, GMS software, and the genetic resources of tropical fruits; (ii) establishing a regional Center of Excellence for training on *in vitro* conservation and cryopreservation at NBPGR, India; (iii) promoting post-graduate courses on PGR in India and Sri Lanka; (iv) establishing a website; (v) developing the South Asia component of the SSEEA regional PGRFA conservation strategy; and (vi) the joint evaluation of finger millet in Bangladesh, India, Nepal and Bhutan. Several meetings have been held and the proceedings published. A Steering Committee was constituted in 2002 to oversee network activities and the implementation of action plans.

Europe

Collaboration among European PGR programmes has further strengthened since the publication of the first SoW report, as a result of increased support from many individual countries as well as from the European Union. Bioversity International has continued to host the secretariats of the ECPGR, the main network on PGRFA in Europe, as well as the European Forest Genetic Resources Network (EUFORGEN). In addition to ECPGR, the Nordic Countries have a collaborative programme on genetic resources (NordGen) that includes a common genebank, and a new networking programme on PGRFA was established in 2004 in southeastern Europe.

- European Cooperative Programme for Genetic Resources (ECPGR):[21] ECPGR is a joint programme of about forty European countries that aims to facilitate the conservation and use of PGRFA in Europe and strengthen links between Europe and elsewhere in the world. It is structured into nine networks (six crop networks and three thematic networks) and implements activities through working groups and task forces. ECPGR collaborates with regional programmes such as the European System of Cooperative Research Networks on Agriculture (ESCORENA). ECPGR members are currently setting up A European Genebank Integrated System (AEGIS)[22], a programme that aims to rationalize collections (see Chapter 7.3.3) as well as EURISCO,[23] a globally accessible catalogue, launched in 2003, that contains information on more than 1.1 million accessions.

- The Nordic Genetic Resources Centre (NordGen):[24] NordGen is a collaborative intergovernmental institution that aims to conserve and document PGRFA and promote collaboration in animal and forest genetic resources of the Nordic countries[25]. It was established in 2008 as a result of a merger between the Nordic Genebank, the Nordic Forestry Resource, and the Nordic Animal Genetic Resource Institute.

- South East European Development Network on Plant Genetic Resources (SeedNet): This network which was set up in 2004 operates in South-East European countries and aims to promote the long-term conservation and use of PGR through creation of national programmes and gene bank facilities. The core of the network consists of a number of crop-specific and thematic working groups.

Near East

The Near East region, which includes Central Asia, the Caucasus, West Asia and North Africa, has seen both good progress and also some stagnation in the period since the first SoW report was published. In Central Asia and the Caucasus, the regional PGRFA network CACN-PGR has been brought under the auspices of the Central Asia and Caucasus Association of Agricultural Research Institutions (CACAARI),[26] which was established in 2004.

- The Central Asian and Caucasian Network on Plant Genetic Resources (CACN-PGR):[27] This network, established in 1999, involves eight countries[28] and has nine crop working groups. It is backstopped jointly by ICARDA and Bioversity International. A regional database has been set up that includes passport data for almost 120,000 accessions and a regional PGR strategy has been developed with support from the GCDT.

- West Asia and North Africa Genetic Resources Network (WANANET): WANANET was originally set up as a regional network to help strengthen PGRFA activities in West Asia and North Africa. Unfortunately, due to lack of resources it is currently defunct. A regional strategy for the conservation of PGRFA was developed in 2006 under the GCDT initiative, with technical support from ICARDA and Bioversity International, that highlighted the importance of networking in the region. AARINENA[29] has established a new network on PGR in 2008.

6.2.2 Crop-specific networks

There is a vast range of international crop-specific networks operating regionally or globally. Most have some aspect of crop improvement as their primary focus, although they may also involve the conservation of PGRFA. They range from relatively straightforward mechanisms for distributing breeding materials, multilocation testing and the sharing of information and results, to fully collaborative research networks in which the comparative advantages of the participating institutions are brought to bear on a common problem or issue. Many of the networks that have international germplasm distribution and collaborative testing as their primary focus are coordinated by the IARCs, and some of these are mentioned in the section on international organizations below. A few examples are given here of new, crop-specific networks that have come into existence or have developed significantly since the first SoW report was published.

The International Network for Bamboo and Rattan (INBAR)[30] was established in 1997 to promote the improved production, processing and trade of bamboo and rattan. INBAR facilitates a global network of partners from the government, private, and not-for-profit sectors in over 50 countries. The conservation and sustainable use of bamboo and rattan genetic resources are an important part of INBAR's programme.

In 2006, the Global Cacao Genetic Resources Network (CacaoNet)[31] was launched as a network of institutions that collaborate in the conservation and use of cacao genetic resources. Its membership includes a wide range of international and regional public institutions as well as the Biscuit, Cake, Chocolate and Confectionery Association (BCCCA), the Cocoa Producers Alliance (COPAL), the International Cocoa Organization (ICCO), the International Group for the Genetic Improvement of Cocoa (INGENIC) and the World Cocoa Foundation (WCF).

The International Network for the Improvement of Banana and Plantain (INIBAP) established a number of regional networks on banana and plantain in the late 1980s and early 1990s. Since the first SoW report was published, a number of important changes have taken place. The Réseau Musa pour l'Afrique Centrale et Occidentale (MUSACO) was founded in 1997 at the invitation of the WECARD/CORAF, and the Banana Research Network for Eastern and Southern Africa (BARNESA) became a network under the auspices of ASARECA. The Latin America and Caribbean Network (LACNET) was renamed the Plantain and Banana Research and Development Network for Latin America and the Caribbean (MUSALAC)[32] in 2000 and now operates under FORAGRO. Likewise, the INIBAP Asia-Pacific Network (ASPNET) was renamed the Banana Asia Pacific network (BAPNET)[33] in 2002 and now operates under the auspices of APAARI. INIBAP itself was formally incorporated, together with IPGRI, within Bioversity International in 2006.

Within the Americas, the Latin American/Caribbean Consortium on Cassava Research and Development (CLAYUCA)[34] was established in 1999 as a regional mechanism to facilitate cassava research and development through the participation of stakeholders from both the private and public sectors. Located on CIAT's campus in Colombia, CLAYUCA is also building links between LAC and African countries for technology development, training, germplasm distribution and the dissemination of information.

In Asia several new networks have been established since 1996, such as the Taro Genetic Resources Network (TaroGen),[35] which was set up in 1998 by the Secretariat of the Pacific Community (SPC) in collaboration with Bioversity International and the University of South Pacific (USP), Samoa. The Cereals and Legumes Asia Network (CLAN), originally founded as the Asian Grain Legumes Network, added cereals to its responsibilities in 2002. It now covers work on sorghum, pearl millet, chickpea, pigeonpea, groundnut, lentil and mungbean and has a membership of 13 Asian countries as well as three IARCs. CLAN's major focus has been on collaborative research, technology development and training, and to date it has been involved in the release of 36 improved varieties

Within the Near East, AARINENA has sponsored various crop-specific initiatives on PGFA since the 1996, including convening networks on date palm, olive, and medicinal plants. The Inter-regional Network on Cotton in Asia and North Africa (INCANA) was established in 2002 with support from GFAR, AARINENA, APAARI, CACAARI, ICARDA and AREO (Iran).

In addition, several new crop networks have been established at the global level that aim to generate and share genomic information on particular crops or groups of crops. These include, for example, the International Coffee Genome Network ICGN[36] and the collaborative international Rice Genome Sequencing Project.

6.2.3 Thematic networks

As indicated above, many new thematic networks have been established in recent years that carry out cooperative activities relating to PGRFA. Again these are far too numerous to cover in detail and just a few examples are presented here of networks that are either new or have undergone significant change since 1996.

Since 2001, three new networks have been established specifically to promote and support the development of the seed sector in Africa: the Africa Seed Network (ASN)[37], the SADC Seed Security Network (SSSN)[38] and the West Africa Seed Network (WASNET). In 2001, the New Partnership for African Development (NEPAD) was created which, among other initiatives, promoted the establishment of four biosciences networks: Biosciences East and Central Africa (BECA), the West Africa Biosciences Network (WABNET), the South African Network for Biosciences (SANBio), as well as the North Africa Biosciences Network (NABNET). SANBio, as mentioned in the Zimbabwe country report, has been particularly active in the area of PGRFA, having devoted attention to creating facilities for conserving vegetatively propagated crops, molecular characterization, and promoting regional collaboration.

Within the Americas, new thematic networks established since 1996 include: the Network on Plant Biotechnology in Latin American and the Caribbean (REDBIO) which promotes the use of biotechnology for crop improvement and genetic conservation, and the Agricultural Innovation Network (REDSICTA), a networking project of IICA in cooperation with the Swiss Agency for Development and Cooperation (SDC). A key aim of REDSICTA is to improve seed production in LAC as illustrated in the Nicaragua country report.

NGOs have also played a greater role over the last 10 years in networking. The Community Biodiversity Development Conservation (CBDC)[39] programme, for example, which involves a number of countries in Africa, Latin America and Asia, is spearheaded by several local and international NGOs. CBDC brings governmental institutions and NGOs together at the global, regional and national level and has a major focus on the conservation, use, marketing and, where necessary, restoration of traditional germplasm resources.

6.3 International organizations and associations with programmes on PGRFA

There is a large range of international and regional associations that, while not exclusively focussed on PGRFA, nevertheless have significant programmes that involve plant genetic resources. Arguable the two largest and most important of these are FAO and the CGIAR, and developments in each of these are given in the following sections. This is followed by a brief consideration of developments that have taken place since the first SoW report in other international and regional organizations, in international fora and associations, in bilateral arrangements and within the NGO community.

6.3.1 FAO's initiatives on PGRFA

FAO has remained very active in promoting and supporting activities on PGRFA since the first SoW report was published, and it has made significant progress in a number of key areas. FAO supports both the Secretariat of the Commission on Genetic Resources for Food and Agriculture (CGRFA) and the Secretariat of the ITPGRFA.

The CGRFA, established as an intergovernmental forum in 1983, has overseen the creation and development of the Global System for the Conservation and Sustainable Use of Plant Genetic Resources. This System, managed and coordinated by FAO, aims to ensure the safe conservation, and promote the availability and sustainable use of plant genetic resources. The first SoW report described the major elements of the System and only the most significant developments are reported below. The Global Plan of Action provides the overall framework or blueprint for the Global System and the periodic State of the World reports provide a mechanism for monitoring progress and evaluating the System. The Basic agreement and inter-governmental policy instrument that underpinned the development of the Global System was, until 2004, the International Undertaking on Plant Genetic Resources for Food and Agriculture. This was superseded when the ITPGRFA came into force. The ITPGRFA is covered in considerable detail in Chapter 7.2.2 and is only mentioned briefly below.

- The Commission on Genetic Resources for Food and Agriculture (CGRFA):[40] The CGRFA is a forum for governments to discuss and negotiate matters relevant to genetic resources for food and agriculture. It reviews and advises FAO on policy matters, programmes and activities. Currently, 168 states and the EU are members of the CGRFA, which is the only intergovernmental body that specifically deals with all components of biological diversity for food and agriculture. The CGRFA started out as the Commission on Plant Genetic Resources and only in 1995 took on responsibility for other components of agricultural biodiversity. In 1997, recognizing the separate needs of the different components, the Commission established two International Technical Working Groups, one on plant genetic resources and the other on animal genetic resources.

  The Commission provided the forum for the successful negotiation of the ITPGRFA, a legally-binding international agreement that came into force in June 2004 (see Chapter 7.2.2). The Commission acted as the Interim Committee for the ITPGRFA until 2006, when its own Governing Body was established. At its eleventh regular session in June 2007, the Commission adopted a rolling ten-year programme of work, which foresees the publication of the first report on the State of the World's Biodiversity for Food and Agriculture, and the integration of the ecosystem approach into biodiversity management in agriculture, forestry, and fisheries.

- International Network of *Ex Situ* Collections: As described in the first SoW report, in 1994 eleven international agricultural research centres of the CGIAR signed agreements with FAO, acting for the CGRFA, bringing their *ex situ* germplasm collections within the International Network of *Ex Situ* Collections. These agreements, and indeed the International Network as a whole, were superseded in 2006 when the centres signed further agreements with FAO, this time acting on behalf of the Governing Body of the ITPGRFA. The new agreements bring all the *ex situ* collections of PGRFA held by the centers (approximately 650,000 accessions of the world's most important crops) within the multilateral system of access and benefit sharing of the ITPGRFA.

- The Global Partnership Initiative for Plant Breeding Capacity Building (GIPB):[41] Launched in 2006, GIPB is an initiative whose primary aim is to strengthen and support the capacity of developing countries to conduct and benefit from plant breeding. It is a partnership that involves many agricultural research, education and development institutions working. Further information on GIPB is to be found in Chapters 4.4 and 7.3.2.

- Relationship with the Convention on Biological Diversity: One area in which significant progress has been made is in the strengthening of the relationship with the Convention on Biological Diversity. A Memorandum of Cooperation was signed between FAO and the CBD in 2006, putting in place a practical framework for increased synergy between the two organizations in the area of biodiversity of relevance to food and agriculture.

6.3.2 The International Agricultural Research Centres of the Consultative Group on International Agricultural Research[42]

The first SoW report described the then 16 - now 15[43] - International Agricultural Research Centres supported by the CGIAR. Over the past few years the CGIAR System has been going through a major process of reform in its vision, governance, funding and partnerships.[44] While the reform is designed to lead to a more focused research agenda, to greater coherence among the Centres and to increased collaboration with a wider range of partners, many of the System's major research thrusts will remain. The management of the genetic resources collections will remain a high priority for the System as will the genetic improvement of those food crops that are of greatest importance to the poor in the developing world.

Of the 15 centres, 11 have collections of PGRFA and are involved in one way or another with long-term conservation and plant genetic improvement (see Chapter 3). They not only make available material from their genebanks but also distribute to partners in both developing and developed countries, nurseries of advanced breeding lines, early generation segregating populations, parental materials, and lines with special characteristics (see Chapter 4.2). At the System level, there have been a number of significant developments since the first SoW report was published. These include a greater emphasis in the breeding programmes on biotechnological tools and methods, including genomics, proteomics, marker-assisted selection and the like; greater attention to participatory breeding approaches; major new partnership programmes for crop genetic improvement such as the Generation Challenge Programme and Harvest Plus (see Chapter 4.7.4 and Box 4.1); and a large, system-wide initiative, now in its second phase, that aims to upgrade the collections and genebank facilities, known as "Collective Action for the Rehabilitation of Global Public Goods in the CGIAR Genetic Resources System".[45]

The Centres have also continued to be heavily involved on an individual basis in a wide range of activities on the conservation and use of PGRFA. A large percentage of these involve international collaboration. By way of illustration, a few of many possible examples are given below:

- The Africa Rice Center (formerly WARDA),[46] works with national programmes throughout Africa and provides leadership for the multi-country rice research network in West and Central Africa, ROCARIZ;

- Bioversity International (formerly IPGRI and INIBAP)[47] is exclusively devoted to agricultural biodiversity. It adopted a new strategy in 2006 that, while maintaining a focus on conservation, also gives greater prominence to the sustainable use of genetic resources for human wellbeing. Bioversity International is heavily involved with a large number of networks and partnership arrangements, e.g. it maintains an active association with all of the networks listed in Section 6.2.1 above;

- CIAT[48] and ILRI[49] both have major collections of tropical forages and CIAT has the largest collections in the world of cassava and beans. It facilitates a number of networks, for example the Pan-African Bean Research Alliance (PABRA);

- CIMMYT[50] maintains international germplasm collections of wheat and maize and facilitates crop improvement networks for both crops. It also plays a leading role in the Asian Maize Biotechnology Network;

- CIP[51] provides leadership for a number of regional networks on potato and/or, sweet potato as well as the Potato Gene Engineering Network (PotatoGENE);

- ICARDA[52] has helped establish genebanks in Morocco, Azerbaijan, Georgia, Armenia, Kazakhstan, Kyrgyzstan, Turkmenistan, Tajikistan and Uzbekistan. The significant contribution of ICARDA in the establishment of genebanks is recognized and described in the country reports of Morocco, Azerbaijan, Armenia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan;

- ICRISAT[53] works closely with national programmes in both Asia and Africa to promote germplasm conservation, enhancement and use. It plays a leadership role in the Cereal and Legume Asia Network (CLAN);

- IITA[54] has important collections of many tropical crops and works in close collaboration with national programmes, networks and other institutions throughout Sub-Saharan Africa;

- IRRI[55] convenes the International Network for the Genetic Evaluation of Rice (INGER)[56] and the Council for Partnerships on Rice Research in Asia (CORRA);[57] and

- The World Agroforestry Center, (formerly ICRAF), has a Genetic Resources Unit that partners with many institutions throughout Africa and beyond, in the conservation and evaluation of species for agroforestry systems.

As an adjunct to the work of the individual Centres, the System-wide Genetic Resources Programme (SGRP) has been set up as a mechanism to help coordinate policies, strategies and activities across the System. SGRP aims to optimize the CGIAR's efforts in five thematic areas: genetic resources policy, public awareness, information, knowledge and technology development, and capacity building. It has provided a focus for the technical input of the CGIAR to the negotiating process of the ITPGRFA, and for negotiating the agreements with FAO bringing the centres' collections under the purview of the ITPGRFA.

In 2000 the CGIAR established the Central Advisory Service on Intellectual Property (CAS-IP) to assist the centres in managing their intellectual assets in order to maximize public benefit.

6.3.3 Other international and regional research and development organizations

There are a very large number of regional and international organizations involved in one way or another with the conservation and use of PGRFA. They range from highly technical international research institutes to the SGSV, a safety back-up facility for the storage of duplicate samples of accessions held in seed collections (see Chapter 3.4). Just four examples of regional and international institutions are given below: two of which are new since the first SoW report was published and two are important agricultural research institutions that have gone through significant changes over recent years.

- Center for Tropical Agricultural Research and Education (CATIE):[58] CATIE is an intergovernmental regional research and higher education centre located in Costa Rica. While it seeks primarily to serve its member countries,[59] it maintains germplasm collections of global importance. Since the publication of the first SoW report CATIE has signed agreements with FAO bringing the collections within the International Network of

Ex Situ Collections (see above). Both conventional seed as well as extensive field collections are maintained, with some of the most important ones being cacao (*Theobroma spp.),* coffee (*Coffea* spp)*,* peach palm *(Bactris spp.)*, peppers *(Capsicum spp.),* cucurbits *(Cucurbitaceae),* and tomato *(Lycopersicon spp.),* as described in the El Salvador, Guatemala and Nicaragua country reports.

- The World Vegetable Center (formerly AVRDC):[60] Headquartered in Asia, the World Vegetable Center maintains collections of many important vegetable species and makes them, and materials arising from its breeding programmes, available to the world community in a similar way to those of the CGIAR centres. Since the first SoW report was published it has greatly expanded its activities in other continents, especially in Africa. It has set up and supported a large number of different regional and international networks.

- Crops for the Future:[61] Created in 2008 as a result of a merger between the International Centre for Underutilized Crops and the Global Facilitation Unit for Underutilized Species, Crops for the Future seeks to promote and backstop research on those neglected and under-utilized species which are considered to have a high potential for contributing to food security, poverty alleviation and protecting the environment.

- International Centre for Biosaline Agriculture (ICBA):[62] ICBA was established in 1999 to address growing concerns about water availability and quality, initially in the WANA region but more recently at the global level as well. ICBA maintains and distributes an international germplasm collection comprising more that 9,400 accessions of some 220 saline and drought-tolerant species of crops and forages.

6.3.4 International and regional fora and associations

Regional and international associations and fora are becoming an increasingly important feature of international cooperation throughout the world, and in almost all areas of society. In fields related to agriculture, and that include activities on PGRFA, such associations they include industry associations such as the International Seed Federation[63] and CropLife International;[64] farmers organizations such as the International Federation of Agricultural Producers;[65] international academic institutions such as the Third World Academy of Science;[66] and environmental networks such as the International Union for Conservation of Nature (IUCN).[67] The regional associations or fora on agricultural research for development have been mentioned in section 6.2 above.

A particularly significant development since the first SoW report was published was the creation in 1999 of GFAR.[68] GFAR is an initiative that provides a neutral platform to promote discussion and collaboration among various stakeholder groups concerned with agricultural research for development. The regional associations and fora are key members of GFAR as are FAO, the CGIAR, farmers' organizations (represented on the Steering Committee by IFAP), civil society groups, private sector organizations, donors and others. GFAR held its first international conference in Dresden, Germany, in 2000, which resulted in the Dresden Declaration that identified genetic resources management and biotechnology as one of GFAR's four priority areas. Participants also drafted a separate declaration specifically on plant genetic resources that urged Governments to meet their obligations to different international instruments, legislation and policies relating to PGRFA. GFAR has also been an active partner of FAO and the CGIAR in facilitating many activities relating to the GPA.

6.3.5 Bilateral cooperation

A large number of different national institutions, in both developing and developed countries, have international programmes in the area of PGRFA, and these have increased significantly since the first SoW was published, as is evident from the country reports. Such bilateral arrangements are far too numerous to list comprehensively and it is only possible to give a very general overview here. Institutions involved in regional and international bilateral activities include universities, national plant breeding and research institutes, genebanks, botanical gardens and the like.

Several developed countries have specialized governmental organizations devoted to providing technical assistance to developing countries. Many of these are involved in agricultural research and development, and initiatives involving the conservation and sustainable use of PGRFA have generally increased over the past decade. Examples include: the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) in France, the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in Germany, the Istituto Agronomico per l'Oltremare (IAO) in Italy and the Japan International Research Centre for Agricultural Sciences (JIRCAS).

The growing importance of south-south cooperation is pointed out in a number of the country reports. Increasingly, institutions in developing countries are taking on international responsibilities, within the context of regional and international networks as well as in their own right. This is particularly true of universities and two examples are given in Chapter 4, Box 4.1: the African Centre for Crop Improvement (ACCI) established by the University of KwaZulu-Natal, and the West African Centre for Crop Improvement (WACCI) established by the University of Ghana. Some Government institutions in developing countries are also expanding their international operations, for example the Chinese Academy of Agricultural Sciences is increasingly posting staff overseas and the Brazilian Agricultural Research Corporation, Embrapa, has set up offices/labs in France, Ghana, Netherlands and USA.

6.3.6 Non-Governmental Organizations

Over the last 10 years, the involvement of NGOs has increased substantially in various aspects of PGRFA and, as with other types of institution, it is impossible to inventory them all. While activities have largely taken place at the national level, international activities have also expanded. For example, NGOs such as Gene Campaign in India, the ETC Group and Grain, among many others, were particularly active internationally when the negotiations were in process for the ITPGRFA, and in the context of various initiatives of the CBD such as those relating to indigenous knowledge, and access and benefit sharing.

Since the first SoW report was published, a number of new national NGOs have been set up concerned with conserving old varieties, especially ‘heritage’ or ‘heirloom’ varieties of fruits and vegetables. This has in turn led to the creation of umbrella organizations and networks such as Safeguard for Agricultural Varieties in Europe (SAVE Foundation). Botanical gardens have also grown in number and strength over the past decade (see Chapter 3.9), and this has been reflected in the growth in membership of the umbrella organization, Botanic Gardens Conservation International, which today includes some 700 members from almost 120 countries.

In addition to NGOs that focus primarily on plant diversity such as those mentioned above, many developmental NGOs, both national and international, are also involved in the conservation and use of PGRFA - for example through projects that promote the management of PGRFA on farm or that promote traditional and high value crops and value added products. In an attempt to promote greater collaboration among such NGOs, a number of regional and international networks have been established, or expanded in scope, since the first SoW report was published. These include, for example, the Asian NGO Coalition for Agrarian Reform and Rural Development (ANGOC) and the Community Biodiversity Development and Conservation Programme (CBDC) mentioned earlier.

6.4 International and regional agreements

The trend towards stronger regional cooperation in matters relating to PGRFA is reflected in the growing number of regional agreements covering such areas as conservation, plant variety protection, access to genetic resources and benefit sharing. One area that has seen particular progress is phytosanitary regulations and these are covered separately below.
In Africa, regional agreements have been signed on plant variety protection,[69] access and benefit-sharing, farmers' rights,[70] the conservation of natural resources,[71] and safety in the application of biotechnology.[72]

In the Americas, the Andean Community countries have adopted several regional agreements regarding plant genetic resources, two of the most important being the 1996 Decision 391 on a Common Regime on Access to Genetic Resources and the 1993 Decision 345 on Common Provisions on the Protection of the Rights of Breeders of New Plant Varieties. Central American countries have also drafted an agreement on access to genetic and biochemical resources and related traditional knowledge.

In Asia, in 2000, the ASEAN countries agreed on a framework on access to biological and genetic resources, and in 1999 the CIS countries adopted a multilateral agreement on cooperation in the sphere of conservation and management of cultivated plants genetic resources and, in 2001, an agreement on the legal protection of plant varieties.

In Europe, the EU has adopted numerous European Community regulations and directives regulating such areas as seed production and distribution, intellectual property and biosafety. National laws on plant breeders' rights have, for example, been harmonized and an EC variety register established.[73] In the Nordic countries, the Nordic Council of Ministers adopted a Ministerial Declaration on Access and Rights to Genetic Resources in 2003.

Regional and international collaboration regarding phytosanitary issues: In 1997, a new text of the International Plant Protection Convention (IPPC)[74] was adopted. The number of members of IPPC has also risen considerably over the last decade, with 69 countries out of the total membership of 170 having joined since 1996.

The 1997 revision of the IPPC was substantial and aimed to bring it up to date with current phytosanitary practices and in line with the concepts contained in the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).[75] In addition to its implications for international trade, the 1997 text of the IPPC promotes the harmonization of phytosanitary measures and creates a procedure to develop International Standards for Phytosanitary Measures. It also introduces new phytosanitary concepts such as the designation of pest-free areas, the phytosanitary security of export consignments after certification, and pest risk analysis.

The role of regional plant protection organizations (RPPOs) was also strengthened in the 1997. In addition to promoting the objectives of the IPPC, RPPOs act as phytosanitary coordinators for their respective regions, promote harmonization of phytosanitary regulations and develop regional standards based on science and in harmony with international standards.

The first SoW report lists eight regional organizations; there are now ten. Although established in 1994, the Pacific Plant Protection Organization was not mentioned in the first report and the Near East Plant Protection Organization was established in 2009.

6.5 International funding mechanisms

With the growing recognition of the importance and value of PGRFA, an increasing number of donors have provided funds to support activities in this area, some in substantial amounts. One of the most significant funding developments since the first SoW report was published was the creation of the Global Crop Diversity Trust. This specialized funding mechanism, that is also part of the funding mechanism of the ITPGRFA, is described in more detail below, followed by an update on the situation with respect to other multilateral and bilateral funding agencies.

- **Global Crop Diversity Trust (GCDT):**[76] It has long been argued that in order to provide long-term sustainable funding for the conservation of PGRFA, an endowment fund is needed. Such a fund would build, preserve and invest its capital assets while using the interest generated to support conservation efforts around the world. With the adoption of the ITPGRFA in 2001, the way was opened up for the creation of such a dedicated funding mechanism, linked to the ITPGRFA.

  Thus, in 2004, FAO and Bioversity International (acting on behalf of the CGIAR Centres) spearheaded the establishment of the Global Crop Diversity Trust. With its own Executive Board, acting under advice from the Governing Body of ITPGRFA and a Donor Council, the Trust had, by early 2009, obtained total funding pledges amounting to more than US$ 150 million. Funds have been provided by national governments, including some developing country governments, multilateral donors, foundations, corporations and private individuals.

  In addition to managing the endowment, the Trust has also raised funds to support the upgrading of collections and facilities, building human capacity, strengthening information systems, evaluating collections and collecting. Efforts to date have concentrated on *ex situ* conservation and evaluation, and a sizeable initiative has been undertaken, referred to earlier in this chapter, to formulate regional and global collaborative crop conservation strategies. These strategies are used to guide the allocation of the resources made available by the Trust.

  In spite of the success of the Trust to date, there is still some way to go before the endowment fund can be considered large enough for the interest derived from it to be able to ensure that all the world's most important PGRFA are securely conserved.

- **Multilateral and bilateral funding agencies:** While it has not been possible to carry out a detailed inventory and analysis of trends in funding for PGRFA, it is evident that the number of agencies which support the conservation and sustainable use of PGRFA, including plant breeding, has grown somewhat since the first SoW report was published. The CGIAR, for example, now numbers some 47 countries as donors (including 21 developing countries) plus 4 foundations and 13 international and regional donor agencies. The large majority of these funders directly or indirectly support research and development activities involving PGRFA. The Global Environment Facility (GEF) remains a major funder of *in situ* conservation, including the conservation of crop wild relatives, and is the principal funding mechanism of the CBD. The World Bank, a major supporter of the CGIAR, has provided funding not only for the Centres' research programmes but also a substantial injection of funds to bring the genebanks up to standard. Other multilateral funding agencies have also been active in supporting national and international projects and programmes that include activities on PGRFA. These include the Regional Development Banks, European Commission, International Fund for Agricultural Development (IFAD), Islamic Development Bank, OPEC Fund for International Development, United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP).

Special mention should also be made of the Regional Fund for Agricultural Technology (FONTAGRO),[77] an alliance of Latin American and Caribbean countries together with the Inter-American Development Bank (IDB) and IICA, that provides funds to support agricultural research and innovation in member countries. Established in 1998, the Fund currently supports 65 projects, many of which have a genetic resources component.

The number of foundations involved in funding PGRFA, especially those in the USA, has also increased in line with the overall growth of the philanthropic sector. Foundations that are involved in one way or another with funding international activities on PGRFA include the Bill & Melinda Gates Foundation, Gatsby Charitable Trust, Gordon & Betty Moore Foundation, Lillian Goldman Charitable Trust, Kellog Foundation, MacArthur Foundation, Nippon Foundation, Rockefeller Foundation, Syngenta Foundation and the United Nations Foundation.

In addition to multilateral agencies and Foundations, many countries provide bilateral support for projects that include activities on the conservation and use of PGRFA. Some countries have agencies dedicated to supporting research in developing countries, e.g. the International Development Research Centre (IDRC) of Canada, the Australian Centre for International Agricultural Research (ACIAR) and the International Foundation for Science (IFS) of Sweden. Most of the national development assistance agencies of the OECD countries are also active in this area.

6.6 Changes since the first SoW report was published

It is evident from the information presented in this Chapter that regional and international collaboration have advanced very considerably since the first SoW report was published. Many new institutions have been established and old partnerships strengthened. A wide diversity of collaborative approaches and mechanisms has been adopted at the sub-regional, regional and global levels. Key changes that have taken place include:

- Several new regional PGRFA networks have been established, including GRENEWECA for West and Central Africa, NORGEN for North America, CAPGERNET for the Caribbean, PAPGREN for the Pacific, SeedNet for Southwestern Europe, and CACN-PGR for the Central Asia and Caucasus region;

- Other regional PGRFA networks have significantly strengthened their activities, e.g. SANPGR in South Asia, SADC-PGR in southern Africa, and the AEGIS and EURISCO initiatives of the European network ECPGR;

- Many other regional PGRFA networks have not fared as well. While almost all networks need additional resources, insufficient funding was a major factor in the demise of WANANET and represents a major constraint for most of the networks in the Americas as well as Southeast Asia and West Africa;

- Several new crop-specific networks have been established that have significant activities on PGRFA. These include, for example, international networks on cacao, the coffee genome, the rice genome, and bamboo and rattan. New or reformed regionally-focused crop networks include ones on banana and plantain, cassava in the Americas, cereals and legumes in Asia, cassava in the Pacific and cotton in Asia and North Africa;

- Several new thematic networks have been established, focusing on a range of different topics. For example, networks have been created on biotechnology in several regions.

Other topics have included the on-farm management of genetic diversity, and seed production. Three seed networks have been established in Africa alone;

- Arguably the most significant development in international collaboration has been the coming into force in 2004 of the International Treaty on PGRFA (ITPGRFA). FAO supports the Secretariats of both the ITPGRFA and the Commission on GRFA (CGRFA). Relationships with the CBD were strengthened with the signing of a joint Memorandum of Cooperation in 2006;

- FAO has further strengthened its activities in the PGRFA area, for example it established the Global Partnership Initiative on Plant Breeding Capacity Building (GIPB) in 2006;

- The International Centres of the CGIAR have concluded new agreements with FAO, acting on behalf of the Governing Body of the ITPGRFA, bringing their collections within ITPGRFA's multilateral system of access and benefit sharing. The CGIAR itself has been going through a period of major reform;

- The CGIAR centres have continued to work collaboratively with a very large number of partners, especially in developing countries, and have continued to make available a wide range of genetic materials. A major programme has been undertaken to upgrade the collections and genebank facilities. In 2000 the CGIAR established the Central Advisory Service on Intellectual Property (CAS-IP);

- Several other new international institutes have been established that undertake research involving PGRFA. These include Crops for the Future and the International Center for Biosaline Agriculture (ICBA);

- The Svalbard Global Seed Vault, which opened in 2008, represents a major new collaborative initiative to improve the safety of germplasm collections, through providing secure facilities for storing duplicate samples of seed accessions;

- Another significant development since the first SoW report was published is the creation in 1999 of the Global Forum on Agricultural Research (GFAR). It promotes discussion and collaboration among different stakeholder groups concerned with agricultural research. GFAR has identified genetic resources management and biotechnology as one its four priority areas;

- The trend towards stronger cooperation is reflected in the growing number of regional agreements covering such areas as conservation, plant variety protection, access to genetic resources and benefit sharing. One area that has seen particular progress is in phytosanitary regulations;

- Several new foundations now support activities in PGRFA internationally. A special fund to support agricultural research in Latin America (FONTAGRO) was set up in 1998 and in 2004 the GCDT was established as a specialized fund dedicated to supporting the conservation of PGRFA and promoting its use worldwide.

6.7 Gaps and Needs

In spite of the impressive progress made since the first SoW report was published, there are still a number of gaps and concerns that need to be addressed as a matter of urgency. These include:

- Although several new networks have been formed, many others have suffered from a lack of funds. At least one has ceased to function. New and innovative funding strategies and mechanisms are needed;

- In order to underpin such funding strategies, increased efforts are needed to raise awareness among policy makers and the general public of the value of PGRFA, the interdependence of nations and the importance of supporting increased international collaboration;

- Greater collaboration is also needed among policy and funding bodies at the international level, and a greater awareness of the need for long-term financial support;

- With the strengthening of the regional and global fora on agricultural research, their influence with national policy makers has grown and they offer valuable opportunities for promoting appropriate national and regional policies in areas of importance to the conservation and use of PGRFA;

- Given that international germplasm exchange is a key motivation behind many networks, additional attention is needed both in promoting the effective implementation of ITPGRFA's multilateral system of exchange and benefit sharing, as well as in developing arrangements for crops that are not currently included in the system;

- In order to benefit from many of the regional and international opportunities for collaboration, there is a need in many countries for greater internal coordination among different ministries and institutions, and between the public and private sectors.

Table 6.1 Regional multi-crop plant genetic resources networks around the world

Region	Sub-regions included (all or part)	Network title (acronym)	Umbrella regional research association or forum	Institution responsible for coordination
Africa	East Africa, Madagascar	The East African Plant Genetic Resources Network (EAPGREN)	ASARECA	ASARECA
Africa	West Africa, Central Africa	Genetic Resources Network for West and Central Africa (GRENEWECA)	CORAF/WECARD	Bioversity International
Africa	Southern Africa, Madagascar, Mauritius	SADC Plant Genetic Resources Network (SADC-PGRN)	SADC	SPGRC
Americas	South America	The Andean Network on Plant Genetic Resources (REDARFIT)	PROCIANDINO	INIA-Peru (2009)
Americas	Central America	Mesoamerican Network on Plant Genetic Resources (REMERFI)	SICTA	SICTA
Americas	Caribbean	The Caribbean Plant Genetic Resources Network (CAPGERNET)	PROCICARIBE	CARDI
Americas	North America	The Plant Genetic Resources Network for North America (NORGEN):	PROCINORTE	INIFAP (2009)
Americas	South America	The Plant Genetic Resources Network for the Southern Cone (REGENSUR):	PROCISUR	INIA-Uruguay (2009)
Americas	South America	The Amazonian Network for Plant Genetic Resources (TROPIGEN):	PROCITROPICOS	PROCITROPICOS
Asia and the Pacific	East Asia	Regional Network for Conservation and Use of Plant Genetic Resources in East Asia (EA-PGR)	APAARI	Bioversity International
Asia and the Pacific	Pacific	The Pacific Agricultural Plant Genetic Resources Network (PAPGREN)	SPC	SPC
Asia and the Pacific	South Asia	South Asia Network on Plant Genetic Resources (SANPGR)	APAARI	Bioversity International
Asia and the Pacific	Southeast Asia	Regional Cooperation in South East Asia for PGR (RECSEA-PGR)	APAARI	Bioversity International
Europe	Europe	European Cooperative Programme for Genetic Resources (ECPGR)		Bioversity International
Europe	Nordic region	The Nordic Genetic Resources Centre (NordGen)	Nordic Council of Ministers	NordGen
Europe	Southeast Europe	South East European Development Network on Plant Genetic Resources (SEEDNet)		Swedish Biodiversity Centre
Near East	Central Asia and Caucasus	The Central Asian and Caucasus Network on Plant Genetic Resources (CACN-PGR)	CACAARI	Bioversity International
Near East	West Asia and Southeast Asia	West Asia and North Africa Genetic Resources Network (WANANET)*	AARINENA	ICARDA

*Now defunct, a new PGRFA network is being established by AARINENA

[1] www.fara-africa.org
[2] www.asareca.org/eapgren/
[3] Burundi, DR Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda
[4] www.coraf.org/English/English.html
[5] http://www.spgrc.org/
[6] www.iica.int/foragro
[7] webiica.iica.ac.cr/prociandino/red_redarfit.html
[8] Bolivia, Colombia, Ecuador, Peru and Venezuela
[9] Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama
[10] Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay
[11] Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Surinam and Venezuela
[12] www.apaari.org
[13] papgren.blogspot.com/
[14] Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, New Caledonia, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu
[15] www.recsea-pgr.net/
[16] Indonesia, Malaysia, Philippines, Papua New Guinea, Thailand, Singapore and Vietnam
[17] www.bioversityinternational.org/scientific_information/information_sources/networks/ea_pgr.html
[18] China, DPR Korea, Republic of Korea, Mongolia and Japan
[19] www.bioversityinternational.org/scientific_information/information_sources/networks/sanpgr.html
[20] Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka
[21] www.ecpgr.cgiar.org/
[22] www.ecpgr.cgiar.org/AEGIS/AEGIS_home.htm
[23] eurisco.ecpgr.org/
[24] www.nordgen.org/index.php/en/
[25] Denmark, Finland, Iceland, Norway and Sweden
[26] www.cacaari.org
[27] www.cac-biodiversity.org/main/main_meetings.htm
[28] Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan
[29] www.aarinena.org
[30] www.inbar.int
[31] www.cacaonet.org
[32] www.bananas.bioversityinternational.org/content/view/75/105/lang,en/
[33] bananas.bioversityinternational.org/
[34] www.clayuca.org
[35] www.spc.int/TaroGen/
[36] www.coffeegenome.org/
[37] www.african-seed.org/
[38] www.sdc.org.za/en/Home/Domains_of_Intervention_and_Projects/Natural_Resources/SADC_Seed_Security_Network_SSSN
[39] www.cbdcprogram.org
[40] www.fao.org/ag/cgrfa/
[41] km.fao.org/gipb/
[42] www.cgiar.org/
[43] The programmes of ISNAR were taken over by IFPRI in 2004
[44] www.cgiar.org/changemanagement/
[45] www.sgrp.cgiar.org/?q=node/583
[46] www.warda.org
[47] www.bioversityinternational.org/
[48] www.ciat.cgiar.org
[49] www.ilri.org/
[50] www.cimmyt.org/
[51] www.cipotato.org
[52] www.icarda.org/
[53] www.icrisat.org/
[54] www.iita.org
[55] www.irri.org/

[56] seeds.irri.org/inger/index.php
[57] www.irri.org/corra/default.asp
[58] www.catie.ac.cr
[59] Mexico, Dominican Republic, Guatemala, Honduras, El Salvador, Belize, Nicaragua, Costa Rica, Panama, Venezuela, Colombia, Bolivia and Paraguay
[60] www.avrdc.org/
[61] www.cropsforthefuture.org/
[62] www.biosaline.org/
[63] www.worldseed.org
[64] www.croplife.org
[65] www.ifap.org
[66] www.twas.ictp.it/
[67] www.iucn.org
[68] www.egfar.org/
[69] Agreement Revising the Bangui Agreement of March 2, 1977, Annex X, 1999
[70] AU Model Law on Rights of Local Communities, Farmers, Breeders and Access, 2001
[71] African Convention on the Conservation of Nature and Natural Resources (Revised version), 2003
[72] African Union: African Model Law on Safety in Biotechnology, 2001.
[73] Council Regulation (EC) No 2100/94 of 27 July 1994 on Community plant variety rights
[74] https://www.ippc.int/IPP/En/default.jsp
[75] http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm
[76] www.croptrust.org
[77] www.fontagro.org

Chapter 7

Access to plant genetic resources, the sharing of benefits derived from their use and the realization of farmers' rights

7.1 Introduction

Access and benefit sharing (ABS), together with conservation and sustainable use, are at the heart of both the CBD and the ITPGRFA. In a world where countries are interdependent among each other for the plant genetic resources they need to sustain food production and to meet the increasing challenges of disease and climate change, access to those resources is essential for achieving world food security. This Chapter reviews the changes that have taken place since the first SoW report was published. It covers the international legal and policy framework relevant to ABS and developments in ABS at the national level. It then reviews developments in the realization of farmers' rights under the ITPGRFA.

7.2 Developments in the international legal and policy framework for ABS

The international legal and policy framework is an area that has undergone, and is still undergoing, very significant change since the first SoW report. Its dynamic nature has influenced, and will continue to have a major influence on progress made in all areas of the conservation and use of PGRFA.

7.2.1 The Convention on Biological Diversity

The CBD continues to provide the legal and policy framework for ABS for genetic resources in general. The main developments in the CBD framework since the first SoW report have been in the context of the work on ABS initiated by the Fourth Conference of Parties (COP 4) in 1999 and carried out principally by a Working Group on ABS established in 2000. The first product was the non-binding Bonn Guidelines on ABS adopted at COP 6 in 2001 (Decision VI/24). The Bonn Guidelines were designed to assist countries in developing and drafting policies, laws, regulations and contracts covering access to PGRFA and the sharing of any benefits that result from their use (see Box 7.1).

In 2004, the Working Group on ABS was mandated by COP 7 to negotiate an international regime on access to genetic resources and benefit sharing (Decision VII/19) that is to include the respect, preservation and maintenance of traditional knowledge, innovations, and practices related to genetic resources. Elements to be considered included the possibility of requiring disclosure of the origin/source/legal provenance of genetic resources and associated traditional knowledge in applications for Intellectual Property Rights (IPR), and the proposal for an international certificate of origin/source/legal provenance that might provide proof that resources were obtained according to the national legislation of countries of origin and with the prior informed consent of the Contracting Parties providing such resources. The Working Group reported its progress to COP 8 in March 2006. Progress on the development of the new regime has been somewhat slower than anticipated, with differences focusing on issues such as the legal status of the proposed new regime. The question of whether the international ABS regime will accommodate sector-specific regimes such as the multilateral system for ABS in the ITPGRFA is also an important issue that still needs to be addressed. COP 9 in 2008, however, agreed on a road map and basic framework including key elements of the International Regime, and called for the Working Group to complete its negotiations before COP 10 in 2010 (Decision IX/12). It was also decided to establish groups of technical and legal experts on (i) compliance, (ii) concepts, terms, working definitions, and sectorial approaches, and (iii) traditional knowledge associated with genetic resources.

7.2.2 The International Treaty on Plant Genetic Resources for Food and Agriculture

One of the most important developments in the plant genetic resources sector since the first SoW report was published has been the adoption and entry into force of the ITPGRFA (see Box 7.2). On the issue of ABS, the ITPGRFA draws together the threads of the International Undertaking on Plant Genetic Resources - a non-binding international instrument that provided for 'unrestricted' availability of plant genetic resources as a common heritage of mankind - and those of the CBD which was based on the principle of national sovereignty over genetic resources and access on the basis of terms that are mutually agreed between the provider and recipient of the resources. The ITPGRFA establishes a Multilateral System of ABS for those plant genetic resources that are most important for food security and on which countries are most interdependent. For such genetic resources, which are listed in Annex 1 of the ITPGRFA, the Contracting Parties have agreed on standard terms and conditions that will govern their transfer for the purpose of research, breeding and training. For those countries that are not yet party to the ITPGRFA, and for PGRFA of crops that are not included in the Multilateral System, the Governing Body of the ITPGRFA may extend the Multilateral System, develop new terms of ABS, or take no action. This may be changed under the new international ABS regime being developed in the CBD.

7.2.2.1 Benefit sharing under the Multilateral System

Benefit sharing under the Multilateral System takes place at the multilateral level. Facilitated access to genetic resources that are included in the Multilateral System is itself recognized as a major benefit of the System. Other benefits arising from the use of PGRFA that are to be shared on a 'fair and equitable' basis include:

<u>The exchange of information</u>. This includes catalogues and inventories, information on technologies, and results of technical, scientific, and socio-economic research on PGRFA including data on characterization, evaluation, and information on use.

<u>Access to and transfer of technology</u>. Contracting Parties agree to provide or facilitate access to technologies for the conservation, characterization, evaluation, and use of PGRFA. The ITPGRFA lists various means by which transfer of technology is to be carried out, including participation in crop-based or thematic networks and partnerships, commercial joint ventures, human resource development, and through making research facilities available. Access to technology, including that protected by IPR, is to be provided and/or facilitated under fair and most-favourable terms, including on concessional and preferential terms where mutually agreed. Access to these technologies is provided while respecting applicable property rights and access laws.

<u>Capacity building</u>. The ITPGRFA gives priority to programmes for scientific education and training in the conservation and use of PGRFA, to the development of facilities for conserving and using PGRFA, and to the carrying out of joint scientific research.

<u>Sharing of monetary and other benefits arising from commercialization</u>. Monetary benefits include payment into a special benefit-sharing fund of the Multilateral System of a share of the revenues arising from the sale of PGRFA products that incorporate material accessed from the Multilateral System. Such payment is mandatory where the product is not readily

available for further research and breeding, for example as a result of patent protection. In the Standard Material Transfer Agreement (SMTA) adopted by the Governing Body at its First Session in 2006, the payment is set at 0.77% of the gross sales generated by the product. The benefit-sharing fund that has been established for the purpose of receiving these revenues will also accept voluntary contributions received from the Contracting Parties, non-contracting parties, and the private sector[1] as part of the benefit-sharing system. The Government of Norway has signified its intention to make a voluntary contribution to the benefit-sharing fund equal to 0.1% of the value of all seeds sold in Norway. Voluntary contributions to the fund have also been announced by the Governments of Spain and Italy. The ITPGRFA Secretariat's first call for proposals under the Benefit-Sharing Fund closed in January 2009 and the first project grants were awarded during the Third Session of the Governing Body in June 2009.

The financial benefits arising from commercialization form part of the Funding Strategy under Article 18 of the ITPGRFA. The Strategy also includes the mobilization of funding from other sources outside the Treaty. An essential element of the Strategy is the GCDT, an international fund that was established in 2004 to help ensure the long-term *ex situ* conservation and availability of PGRFA (see Chapter 6.7).

7.2.2.2 Enforcement of the terms and conditions of the SMTA

One of the issues encountered by countries providing genetic resources under material transfer agreements is the difficulty in enforcing the terms and conditions of those agreements once the said resources have left their own jurisdictions. These difficulties are exacerbated because the monetary benefits flow not to the individual country providing the resources, but to the Multilateral System; the provider of the resources thus has limited direct material interest in enforcing the terms of the agreement. The SMTA provides a mechanism for overcoming these difficulties by empowering FAO, as the entity chosen by the Governing Body to represent its interests as a third party beneficiary, to initiate action where necessary to resolve disputes.

7.2.3 ABS in relation to WTO, UPOV and WIPO

IPR offer one means to promote the sharing of benefits arising from the use of genetic resources equitably among innovators and users of innovations. Recognizing this, the relationship between ABS regimes for genetic resources, traditional knowledge, and the IPR system has been a focus of discussion in the World Trade Organization (WTO) and in particular in the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Council. It has also been under discussion in the International Union for the Protection of New Varieties of Plants (UPOV) and the World Intellectual Property Organization (WIPO).

Article 27.3(b) of the TRIPS Agreement requires TRIPS members to grant protection to plant varieties, either through patents, through an effective *sui generis*[2] system, or through a combination of both. The Agreement provides for a periodical review, including of its interaction with the CBD, in relation to traditional knowledge and folklore. It has become apparent that there is a difference of opinion among TRIPS Council Members as to whether there is any inherent conflict between these two instruments and if so how they could be resolved. One possibility would be to require that a certificate of origin be filed with all relevant patent applications. Article 27.3(b) of the TRIPS Agreement refers in general terms only to an effective *sui generis* system of protection for plant varieties, leaving it open for countries to devise their own *sui generis* system, should they so desire. In practice, most countries have based their protection of plant varieties on the UPOV model, which offers the advantage of mutual recognition among all UPOV members.[3] In its present form, the UPOV model would exclude the imposition of certification of origin as a condition for the granting of plant breeders' rights, as the UPOV Convention precludes the imposition of any conditions other than novelty, distinctness, uniformity, and stability.

WIPO is the United Nations (UN) Specialized Agency dedicated to developing a balanced and accessible international intellectual property (IP) system. In 2000 the WIPO General Assembly established an Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC), to examine, among other things, intellectual property issues arising in the context of ABS and the protection of traditional knowledge, and innovations. At the request of COP 7, the IGC is now examining the relationship between access to genetic resources and disclosure requirements in IPR applications.

7.2.4 FAO and ABS

The FAO Commission on CGRFA at its Eleventh Regular Session in 2007 adopted a Multi-Year Programme of Work which recommended that 'FAO continue to focus on ABS for genetic resources for food and agriculture in an integrated and interdisciplinary manner…'.[4] It decided that its 'work in this field should be an early task within its Multi-Year Program of Work'. In light of this decision, the FAO CGRFA will consider policies and arrangements for ABS for genetic resources at its 12th Session scheduled for the third quarter of 2009. ABS is a cross-cutting issue in the CGRFA, which also addresses the genetic resources of farm animals, microbial and insect genetic resources for food and agriculture, fish genetic resources and forest genetic resources.

7.3 Developments in access and benefit sharing at the national level

7.3.1 Accessing germplasm

There are no reliable figures on the world-wide movement of germplasm for the period since the preparation of the first SoW report. However, figures are available for acquisition and distribution of PGRFA by and from the CGIAR centres (see Chapters 3 and 4).

Little information is contained in country reports on the actual flows of PGRFA to and from individual countries. Ethiopia reports that its national genebank dispatches annually about 5,000 samples nationally and internationally and Venezuela reports that it has received 64 applications for access to PGRFA under the Law on Biological Diversity adopted in 2000.

Such information is also not yet readily available from public databases, although work is progressing on the establishment of a global accession level information system. Several country reports, for example Azerbaijan, New Zealand and Sri Lanka, indicated that having access to PGRFA held by the Centres of the CGIAR was important to them, although India reported a decline in PGRFA from CG centres and other national genebanks after the entry into force of the CBD. Several country reports[5] indicated that access to PGRFA from other sources is becoming more difficult, due in part to a lack of clarity over issues such as ownership and IPR and a need for clearer procedures.

7.3.2 Benefits derived from the conservation and use of PGRFA

As discussed in Chapter 4, to take full advantage of the benefits provided by access to PGRFA requires that developing countries have access to plant breeding capacity. To some extent, such capacity is being provided through the breeding programmes of the CG centres, which operate in close cooperation with the NARS they serve. But there is need for greater breeding capacity in many developing countries, a need that new programmes, such as the GIPB,[6] are helping to address. There is also a need for more fully integrated systems at the national level that provide for effective linkages between conservation, breeding and seed production and distribution, in order to bring the benefits to the farmers themselves, in the form of improved seed.

7.3.3 Development of access and benefit-sharing arrangements at the national level

An overview of the situation regarding the status of access and benefit sharing legislation and regulations is summarized in Box 7.3 for each region. More general problems and issues are discussed in the sections below.

7.3.3.1 General problems and approaches at the national level

One obstacle to regulating access to genetic resources and achieving a fair and equitable sharing of benefits has been the nature of such resources and difficulties in establishing rights over them. These difficulties stem from the intangible nature of genetic resources as compared to physical biological resources.[7]

Traditionally, ownership of genetic resources - in so far as any such ownership was recognized - has been linked to ownership of the biological resource, such as wheat in farmers' fields, or samples in *ex situ* genebanks. Ownership of the intangible genetic resource *per se* was recognized only where they were the consequence of an act of creation, as for example through the granting of IPR over new plant varieties that are the result of breeding processes. The ITPGRFA avoids the issue of ownership entirely, by focusing on terms of access and provisions for benefit-sharing.

The recognition of national sovereignty over genetic resources implies that countries have the power to manage those resources and to regulate access to them, but it does not address the issue of ownership *per se*. While in many countries legal ownership of genetic resources still follows the ownership of land and the biological resources on that land, an increasing number of countries are affirming the separate ownership of genetic resources by the State. Decision 391 of the Andean Community, for example, provides that genetic resources are the property or heritage of the Nation or State. Article 5 of the Ethiopian Proclamation No. 482 of 2006 provides that 'the ownership of genetic resources shall be vested in the state and the Ethiopian people'. The practical consequences of these ownership claims are as yet unclear.

Another obstacle frequently cited by countries in their national reports (more than 35 countries) is the lack of the necessary multidisciplinary scientific, institutional and legal capacity to develop a satisfactory system of ABS, given the interrelated dimensions of access, benefit sharing, local community rights and traditional knowledge, and the connected problems of intellectual property and economic development.[8]

Other difficulties include the overlapping competences of different ministries. The implementation of the ITPGRFA, for example, normally requires coordination between the Ministry responsible for agricultural policies and that responsible for environmental matters, as well as coordination with ministries responsible for trade, land, forests, and national parks where access to PGRFA *in situ* is concerned.

In the case of federal states, the allocation of responsibilities between a federal government and its individual states or provinces may also provide a challenge. In Malaysia, for example, the difficulties caused by the division of responsibilities between the state and federal authorities with respect to genetic resources are specifically noted in the 1998 National Policy on Biological Diversity (paragraphs 16-20). The Malaysia country report notes that while national legislation on ABS was being developed, the States of Sabah and Sarawak had their own process underway which resulted in two State enactments on this matter. In Australia discussions are in progress between that national government and states regarding the way in which Australia will implement the ITPGRFA. In Brazil competence over genetic resources is shared at both federal and state levels, and state laws have been enacted on access to genetic resources.[9] The federal government is responsible for establishing standards and granting import and export permits.

7.3.3.2 National implementation of access and benefit-sharing arrangements under the CBD

The implementation of ABS does not necessarily require the adoption of a legislative framework. Indeed the number of national instruments implementing ABS under the CBD is still relatively limited. Several countries, particularly developed countries, tend to favour a strategy of using administrative policies, and placing few if any legal or regulatory conditions on access to genetic resources, other than those inherent in general property laws (real and intellectual), contract law, forest and wildlife protection laws, and/or under international agreements such as the ITPGRFA. The Nordic Ministerial Declaration of 2003 'Access and Rights to Genetic Resources'[10] is an example of this approach.

The number of laws regulating ABS is however increasing. As of 15 February 2009, the CBD Database on ABS Measures[11] listed 30 countries[12] that had some legislation regulating ABS, of which 22 had adopted new laws or regulations since 2000. The laws are either part of general legislation on the environment or free-standing legislation on biodiversity or genetic resources.

For the most part, ABS legislation tends to be drafted primarily to cover the issues raised by *in situ* bioprospecting including, in particular, access to genetic resources and associated traditional knowledge in indigenous and local communities, although the legislation also applies, sometimes expressly, to accessing genetic resources in *ex situ* conditions.

So far as access regimes are concerned, provisions in national legislation are fairly standard, requiring application to a central authority for permission to access genetic resources and associated local knowledge, prior informed consent of the national authority and the indigenous and local landowners or communities where access is to take place, and arrangements for benefit sharing with both the central authority and the indigenous or local communities concerned. In an increasing number of countries,[13] a distinction is being made between access for research and access for commercial purposes, although the borderline is very difficult to establish. Where the use changes after the initial research, then a new ABS agreement is required, but many innovators hesitate to access genetic resources if they have to renegotiate access as soon as a profitable product may appear on the horizon.

Many countries have no national ABS legislation or policies in place, and a constant theme of many of the Reports from developing countries is the need to develop them.[14] It is not possible to describe all aspects of national arrangements for ABS. This section will therefore concentrate on the following four issues: benefit-sharing arrangements, traditional knowledge and the rights of indigenous and local communities, regional cooperation and compliance.

<u>Benefit-sharing arrangements</u>: In general, there are few - if any - examples of laws and policies that are broadly acknowledged to be successful in generating tangible benefits and that could provide a model for other countries.[15] Most countries with ABS arrangements in

place allow for flexibility in the actual nature of the benefits. This is in line with the thrust of recent studies indicating wide divergences in the practices and interests involved in different sectors that depend on access to genetic resources.[16] There is clearly a need for better market information on the valuation of genetic resources used in different sectors. Recent legislation in some Latin American countries, however, seems to take a different approach, requiring fixed percentages of payments to be made under benefit-sharing arrangements, in addition to nonmonetary benefits.

Costa Rica, for example, requires that up to 10%, of the budget for research and bioprospecting and up to 50% of the royalties obtained from commercialization be paid by the applicant (the actual amounts to be agreed in advance). Under prior informed consent agreements entered into in the period 2004-2006 between the National System of Conservation Areas (SINAC) as provider and the National Institute for Biodiversity as user, SINAC obtained monetary benefits of approximately US$38,387 of which 89.3% resulted from the percentage of the research budget and 10.7% from royalties.

Peru requires that the ABS agreement must foresee an initial monetary payment or equivalent to the providers of traditional knowledge, to be applied to sustainable development, and not less than 5% of the value of the gross sales of products developed from the direct or indirect use of such knowledge. A percentage of not less than 10% of the gross value of the sales of those products must also be paid into the Fund for the Development of Indigenous Peoples.[17]

Whatever particular ABS regimes are applicable, there seems to be general agreement that the benefits derived from those regimes are not substantial in practice, at least in monetary terms. Indeed it seems that the operation of the ABS regimes at present is satisfactory neither to the providers of the resources nor to the users. Some providers have complained that few benefits are received in practice from access, while several users have complained that access is becoming more difficult and restrictive due to inflexible and bureaucratic ABS regimes. The CBD Secretariat-commissioned study on ABS arrangements cited earlier[18] notes frustration in industry at the way in which prior informed consent procedures are implemented, including the designation of focal points that are empowered to act, and the lack of clear-cut rules and knowledge of the value of the material. The same study reports that 'companies within the seed, crop protection and plant biotechnology sectors prefer to avoid using traditional/farmers' knowledge as far as possible because of the legal and ethical complications involved'.[19] These difficulties include the lack of legal certainty over ownership of traditional knowledge, identifying who should provide prior informed consent, and who should receive benefits. In this connection, the industry looks to governments to provide certainty and to help conclude agreements with the indigenous and local communities involved.

Implementation of non-monetary benefit sharing appears to be more successful in practice.[20] Non-monetary benefits include capacity building, access to seeds and propagating material and related information, conservation activities and enhanced use of farmers' varieties, including access, much of which may be achieved outside the framework of national legislation.

<u>Traditional knowledge and the rights of indigenous and local communities</u>: Specific recognition of the rights of holders of traditional knowledge or community knowledge is given in many new ABS enactments. Examples are the African Model Legislation,[21] a proclamation in Ethiopia,[22] and a law in Peru. One new approach has been to provide for the registration of traditional knowledge and to take action against acts of misappropriation. In Peru, this is done through the dissemination of information on the registered rights to patent offices around the world and by taking legal action to oppose IPR being awarded for inventions based on traditional knowledge that has been misappropriated.[23] A new law in Portugal

provides for the registration of local varieties and other indigenous material and of associated traditional knowledge, developed in a non-systematic manner by local populations.[24] Registration allows for the sharing of benefits and some protection against misappropriation. It also implies a corresponding responsibility on the rights holders for the continued *in situ* maintenance of the registered plant material.

Regional Cooperation in the implementation of ABS: The Conference of Parties to the CBD has on a number of occasions stressed the importance of regional cooperation on ABS.[25] A number of initiatives have been taken at the regional level in this respect. Examples are Decision 391 of the Andean Community of 1996 establishing a Common Regime on Access to Genetic Resources, the ASEAN Framework Agreement on Access to Biological and Genetic Resources of 2000, and the African Model Legislation for the Protection of the Rights of Local Communities, Farmers and Breeders and for the Regulation of Access to Biological Resources (OAU Model Legislation), also of 2000. Each of these regional initiatives takes as its starting point the sovereign rights of states over their genetic resources and sets out basic principles for access to genetic resources, including prior informed consent of the national government providing access and of the local communities involved, along the lines of the Bonn Guidelines adopted in 2001. The OAU Model Legislation deals in more detail with the rights of local communities and farmers' rights, and covers also plant breeders' rights. Both the OAU Model legislation and the ASEAN Framework Agreement take the form of guidelines for the establishment of ABS regimes by national governments in the region; however no African country has yet enacted law following the OAU model. The Andean Community Decision 391, on the other hand, requires each Andean Community member to enact legislation that is consistent with it. To the extent that the regional initiatives set out detailed procedures for ABS based on the bilateral model, there may well be a need for Parties to the ITPGRFA to consider revising them to take into account the Multilateral System of ABS established under the ITPGRFA.

Compliance: One of the problems facing national ABS regimes has been the difficulty in ensuring compliance with and enforcing the conditions placed on the use of the genetic resources, especially once the material has been accessed and has left the country. Taking legal action to enforce the agreed conditions of ABS in foreign courts is very expensive and can be beyond the resources of many countries. Legal recourse may be necessary not only where genetic resources have been accessed in contravention of national legislation or used in contravention of the agreed conditions but also when, following initial research, the material is used for purposes that were not covered in the original agreement, such as commercial exploitation. It was partly for these reasons that the role of the Third Party Beneficiary was conceived in the SMTA under the Multilateral System established under the ITPGRFA.[26]

While the issue of compliance remains complex, the proposal for a certificate of origin/source/legal provenance is one approach being suggested in international fora as a means of alleviating at least some of the concerns, although its feasibility remains in some doubt. The requirement for such a certificate has been taken up in the ABS legislation of a number of developing countries, for example Costa Rica and Panama.

The new European Union Guidelines for Examination in the EPO[27] provides for the legal protection of biotechnological innovations and specifically considers ABS. Rule 27 states that if an invention is based on biological material or if it uses such materials, the application for biotechnological inventions patents should, when appropriate, include information on the geographical origin of the biological materials, if known. The provision thus seeks to support compliance with the national legislation of the country providing the biological material and with all other contractual arrangements governing the acquisition and use of such materials. These rules are not legally binding, and are intended only to help in the interpretation of the binding articles of the Guidelines. However, disclosure of origin requirements have been enacted in the IPR legislation of a number of EU member countries, including Belgium, Denmark, Germany, Norway and Sweden.

7.3.3.3 National Implementation of access and benefit sharing under the ITPGRFA

Placing of PGRFA in the Multilateral System: To date, the major collections formally placed in the Multilateral System are those held by the international institutions that have signed agreements with the Governing Body of the ITPGRFA.[28]

So far as national collections are concerned, Article 11.2 of the ITPGRFA provides that PGRFA of crops and forages listed in its Annex 1 that are under the management and control of the Contracting Parties and in the public domain, are to be included automatically in the Multilateral System. Other holders of PGRFA listed in Annex 1 are invited to place them in the Multilateral System, and Contracting Parties agree to take appropriate measures to encourage them to do so. While the ITPGRFA itself does not clearly and explicitly place an obligation on Contracting Parties to disseminate information on the material included automatically or voluntarily in the Multilateral System, it is clear that the accessibility of such material will depend in practice on the relevant information being available. For this purpose, the ITPGRFA Secretariat has formally requested Contracting Parties to provide information on the materials within the Multilateral System in their jurisdictions.[29] Updated information on the accessions included in the Multilateral System is available at the Secretariat of the ITPGRFA.[30]

In addition Canada and Switzerland have also provided information on material included in the Multilateral System, as well as at least one private breeders' association in France.[31]

From the information available, it appears that there may be differences in the interpretation of the criteria of 'under the management and control of Contracting Parties' and 'in the public domain'. This matter may need to be referred to the Governing Body for clarification. In the meantime, it appears that wide use is being made of the persuasive powers of governments to encourage holders of non-governmental collections of Annex 1 PGRFA to place their collections in the Multilateral System.[32]

Implementing the Multilateral System through administrative measures: To date a number of countries are choosing to implement the Multilateral System of the ITPGRFA through administrative measures rather than through the adoption of new national legislation. This is the case, for example, in both the Netherlands and Germany. The implementation of the Multilateral System in Germany (see Box 7.4) is illustrative of the type of administrative measures taken.

Implementing the Multilateral System through legislative measures: While some countries consider that the Multilateral System can be implemented solely through administrative measures, more formal legislative action may be in order, so as to provide legal space in which the implementation can operate, provide for legal authority for the implementation of the System, and/or provide legal certainty as to the procedures to be followed.

The need to provide legal space was identified by the First Consultation of Experts on the SMTA and the Multilateral System of the ITPGRFA[33] as an important reason for considering national legislation on PGRFA. Indeed such legislative action may be necessary where legislation is already in place for the implementation of ABS procedures under the CBD. Legislative action in this context may be limited to the recognition that ABS under the Multilateral System should follow different and simplified procedures, leaving those procedures to be defined by administrative measures or by further legislative action, or else it may enter into the detailed procedures applicable as with other genetic resources or uses.

The legislation of Ethiopia is one example of the first approach, where the legislation provides that access to genetic resources under a multilateral system is to be made in accordance with the procedure specified in the Multilateral System and in accordance with future regulations to be issued on the subject.[34] There are so far no instances of national legislation that set out detailed procedures for dealing with ABS under the Multilateral System. It is known however that a number of countries are considering, or in the process of drafting, such legislation, whether as part of stand-alone legislation on plant genetic resources for food and agriculture, or in the context of national legislation on genetic resources in general.[35]

Regional cooperation in the implementation of the Multilateral System: Reference has already been made above to regional initiatives in the implementation of ABS. A number of regions are also taking cooperative action for the implementation of the Multilateral System. One such initiative is that launched by the Arab Organization for Agricultural Development (AOAD) with the support of FAO and Bioversity International for the development of guidelines and model legislation on the implementation of the ITPGRFA and its Multilateral System in the countries of the Near East region. A workshop held in Cairo in March/April 2009 agreed on a roadmap for the development of the guidelines and their implementation in selected countries in the region.

A second example is the European initiative to establish AEGIS. This system, which has been developed within the framework of the ECPGR, would provide for the establishment of a European Collection, consisting of selected accessions designated by the individual countries. Material designated as part of the European Collection would continue to be conserved in the individual genebanks concerned, but would be maintained in accordance with agreed quality standards and would be made freely available, both within Europe and outside, in accordance with the terms and conditions set out in the ITPGRFA using the SMTA. In so doing, the countries plan to share responsibilities relating to the conservation and sustainable use of PGRFA and thus to develop a more efficient regional system in Europe. Both Annex 1 and non-Annex 1 materials can be designated as part of the European Collection.[36]

A third regional initiative is that underway in the Pacific Region, where the Pacific Island countries have agreed to make Annex 1 material available through their regional genebank, CePaCT), run by the Secretariat of the Pacific Community (SPC). The SPC is in the process of signing an Agreement with the Governing Body under Article 15.5 of the ITPGRFA, placing the regional germplasm collection within the purview of the ITPGRFA.

Access and Availability of PGRFA under the Multilateral System: Table 7.1 provides information on the rates of acquisition and distribution by CGIAR Centres during the first seven months of operation of the system as reported to the Governing Body at its Second Session in 2007.[37]

Table 7.1 Experience of the CGIAR Centres with the SMTA 01/01/2007 – 31/07/2007

Acquisitions	Transfers of raw PGRFA	Transfers of PGRFA under Development	Total transfers	Shipments	Countries	Rejections
3,988	38,210	48,848	97,669	833	155	3

Further information is provided in Table 7.2 on acquisition and distribution by the CG centres during the year commencing 01/08/2007 as reported to the Third Session of the Governing Body.[38]

Table 7.2 Experience of the CGIAR Centres with the SMTA 01/08/2007 – 1/08/2008

Acquisitions	Transfers of raw PGRFA	Transfers of PGRFA under Development	Total transfers	Shipments	% sent to developing countries	% sent to developed countries	Rejections
7,264	95,783	348,973	444,824	3,267	74	6	0

So far there is little information on the flow of germplasm from national sources under the Multilateral System, although it is understood that a number of countries, such as Canada, Egypt, Germany, Syria and The Netherlands, are now starting to distribute Annex 1 materials under the SMTA. The ITPGRFA Secretariat's report to the Third Session of the Governing Body on the implementation of the Multilateral System also provides information on materials made available under emergency disaster situations over the last decade or so.[39]

7.4 Farmers' Rights under the ITPGRFA

The ITPGRFA deals with the issue of the realization of Farmers' Rights, a concept originally launched in the interpretations of International Undertaking on PGR. Recognizing that the responsibility for realizing farmers' rights rests with national governments, Article 9 of the ITPGRFA calls on Contracting Parties to take appropriate measures to protect and promote farmers' rights. For the first time in an international instrument, the possible scope of farmers' rights is clarified, as including: the protection of traditional knowledge relevant to PGRFA; the right of farmers to equitably share benefits that result from their use; their right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of PGRFA; and the right of farmers to save, use, exchange, and sell farm-saved seed/propagating material, subject to national law.

A key way in which farmers benefits from the use of PGRFA is through the breeding and availability of new crop cultivars that are better suited to their needs; to the challenges of pests and diseases, environmental sustainability, climate change and new market opportunities. However, many crop breeding programs tend to emphasize crops that are grown on large acreages or that are grown in commercial production systems (see Chapter 4). Additional efforts are needed in many countries to address the needs of resource-poor farmers who are often the custodians of genetic diversity and hence the intended recipients of benefits that are linked to farmers' rights.

Recent debates on the future implementation of farmers' rights have focused on the distinction between the 'ownership' approach and the 'stewardship' approach. The former places emphasis on the right of farmers to be rewarded for genetic material obtained from their fields and used in commercial varieties, and the latter places emphasis on the rights that farmers need to have in order to allow them to continue as stewards and innovators of agro-biodiversity. Both such approaches are clearly reflected in the present state of national implementation of Farmers' Rights as described in Chapter 5.

The Third meeting of the Governing Body of the ITPGRFA, held in Tunis in 2009,[40] reviewed the state of implementation of Article 9 of the Treaty dealing with farmers' rights. As contracting parties had provided only a small number of submissions, describing the status of implementation, the Secretariat of the ITPGRFA was requested to convene regional workshops on Farmers' Rights to discuss national experiences in implementing the Article. The reports of these meetings, together with the views and experiences submitted by

Contracting Parties and other relevant organizations, will be presented for the consideration of the Fourth Session of the Governing Body.

7.5 Changes since the first SoW report was published

Since the publication of the first SoW report, there has been a great deal of activity with respect to the development of the international and national legal and policy frameworks for ABS. Less progress has been made overall in the implementation of farmers' rights. Major changes that have occurred in these areas include:

- Negotiations have been initiated by the Contracting Parties to the CBD aimed at developing an international regime on ABS. These are scheduled to be finalized by the 10th session of the Conference of Parties in 2010;
- Discussions on matters related to ABS are also taking place in other fora such as the TRIPS Council and WIPO;
- The FAO CGRFA adopted a Multi-Year Programme of Work in 1997 that recommended that 'FAO continue to focus on ABS for genetic resources for food and agriculture in an integrated and interdisciplinary manner…', including PGRFA, along with genetic resources of farm animals, microbes and beneficial insects, fish and forest species;
- Perhaps the most far-reaching development has been the entry into force in 2004 of the ITPGRFA. This international treaty establishes a multilateral system of access and benefit sharing that facilitates access to PGRFA of the most important crops for food security. As of June 2009, 120 countries were party to the ITPGRFA;
- In February 2009, the CBD Database on ABS Measures listed 30 countries with legislation regulating ABS. Of these, 22 had adopted new laws or regulations since 2000. Most of these have been developed in response to the CBD rather than the ITPGRFA.

7.6 Gaps and needs

While much has been achieved, the following lists some of the areas that still require attention:

- At the global level, there is still a great deal of work to be done in international fora on defining a comprehensive international ABS regime. Any new international regime needs to take into account the specific needs of the agriculture sector;
- While the special requirements of PGRFA are provided for in the ITPGRFA, more needs to be done to raise awareness of the importance of the ITPGRFA among governments and to encourage wider participation therein;
- Many countries have expressed the need for assistance - both advice and capacity building - in implementing the ITPGRFA and its Multilateral System for ABS. Assistance is also needed in ensuring a proper interface between the ITPGRFA and the CBD;
- There remain potential difficulties in implementing ABS in the context of material found in *in situ* conditions, even when that material falls within the Multilateral System;
- There is a need for stronger coordination in the development of policies, legislation and regulations among the various ministries, state governments and other institutions having responsibility for different aspects of PGRFA;

- Several countries have expressed the need for assistance in developing policies, legislation, regulations and practical measures for implementing farmers' rights. While a few countries are experimenting in this area, to date there are no well-proven models that could be widely adopted. Existing examples of such legislation need to be evaluated and information made available on their effectiveness and how they function in practice;
- There is a need for better mechanisms to facilitate the participation of rural communities, farmer organizations and other elements of civil society in the formulation of policies and other measures for the realization of farmers' rights;
- One way to realize farmers' rights is through making available better varieties. Plant breeding and seed dissemination systems need to be strengthened and greater attention paid to the needs and circumstances of resource-poor farmers, the guardians of much genetic diversity.

Box 7.1 Potential benefit from access and benefit sharing as listed in the Bonn Guidelines

1. **Monetary benefits** may include, but not be limited to:
(a) Access fees/fee per sample collected or otherwise acquired;
(b) Up-front payments;
(c) Milestone payments;
(d) Payment of royalties;
(e) License fees in case of commercialization;
(f) Special fees to be paid to trust funds supporting conservation and sustainable use of biodiversity; (g) Salaries and preferential terms where mutually agreed;
(h) Research funding;
(i) Joint ventures; and
(j) Joint ownership of relevant intellectual property rights.

2. **Non-monetary benefits** may include, but not be limited to:
(a) Sharing of research and development results;
(b) Collaboration, cooperation and contribution in scientific research and development programmes, particularly biotechnological research activities, where possible in the provider country;
(c) Participation in product development;
(d) Collaboration, cooperation and contribution in education and training;
(e) Admittance to *ex situ* facilities of genetic resources and to databases;
(f) Transfer to the provider of the genetic resources of knowledge and technology under fair and most-favourable terms, including on concessional and preferential terms where agreed; in particular, knowledge and technology that make use of genetic resources, including biotechnology, or that are relevant to the conservation and sustainable use of biological diversity;
(g) Strengthening capacities for technology transfer to user developing country Parties and to Parties that are countries with economies in transition and technology development in the country of origin that provides genetic resources. Also to facilitate abilities of indigenous and local communities to conserve and sustainably use their genetic resources;
(h) Institutional capacity building;
(i) Human and material resources to strengthen the capacities for the administration and enforcement of access regulations;
(j) Training related to genetic resources with the full participation of providing Parties and, where possible, in such Parties;
(k) Access to scientific information relevant to conservation and sustainable use of biological diversity, including biological inventories and taxonomic studies;
(l) Contributions to the local economy;
(m) Research directed towards priority needs, such as health and food security, taking into account domestic uses of genetic resources in provider countries;
(n) Institutional and professional relationships that can arise from an access and benefit sharing agreement and subsequent collaborative activities;
(o) Food and livelihood security benefits;
(p) Social recognition;
(q) Joint ownership of relevant intellectual property rights.

Box 7.2 The International Treaty on Plant Genetic Resources for Food and Agriculture

The Treaty was adopted by the FAO Conference in November 2001 and entered into force in June 2004. It has 120 Contracting Parties as of May 2009. The Treaty, which is in harmony with the CBD, provides generally for the conservation and sustainable use of all plant genetic resources for food and agriculture and for the fair and equitable sharing of benefits derived from its use, taking into account the specific nature and characteristics of plant genetic resources for food and agriculture.

On the issue of **access and benefit sharing**, the Treaty draws together the threads of the International Undertaking with those of the CBD by establishing a **Multilateral System of Access and Benefit-Sharing** for those plant genetic resources that are most important for food security and on which countries are most interdependent. For those genetic resources, which are listed in **Annex 1** to the Treaty, the Contracting Parties to the Treaty have mutually agreed, on a multilateral basis, the terms and conditions that will govern their transfer for the purpose of research, breeding, and training. These terms and conditions are set out in the **Standard Material Transfer Agreement (SMTA)** adopted by the Governing Body at its First Session in June 2006. In this way the Multilateral System reduces the transaction costs inherent in bilaterally negotiated exchanges. The Multilateral System covers automatically all PGRFA of Annex 1 crops that are ‘under the management and control of the Contracting Parties and in the public domain’. Provision is made for the voluntary inclusion of other materials in the Multilateral System by their holders. While the Multilateral System has not yet been fully implemented at the national level, it remains the only functional system of access and benefit-sharing actually in place.

The ***ex situ*** **collections** held by the International Agricultural Research Centres of the CGIAR system and other relevant international institutions, comprising over 650,000 accessions, are also covered by the Treaty, thus settling the question of the status of those collections left open by the CBD. PGRFA of Annex 1 crops are to be made available through the SMTA under the same terms and conditions applicable to collections held by Contracting Parties. Under a decision of the Governing Body at its Second Session in November 2007, non-Annex 1 materials held by the Centres and collected before the entry into force of the Treaty are also to be made available under the same SMTA. Non-Annex 1 material collected after the entry into force of the Treaty will be made available on terms and conditions consistent with those mutually agreed with the country of origin of the material or the country that acquired them in accordance with the CBD or other applicable law**.**

Box 7.3 Status of legislation and regulations on ABS as of February 2009

Africa: Angola, Ethiopia, Gambia, Kenya, Lesotho, Malawi, Nigeria, South Africa, Uganda and Zimbabwe, have all put in place regulations concerning access to genetic resources and draft legislation is under development in Madagascar, Namibia, Seychelles, Tanzania and Zambia. However, with the exception of Angola's law and those being currently drafted, these regulations do not have PGRFA as the main focus but address broader concerns. In 2001, the African Union adopted a model law on the rights of local communities, farmers, breeders and access to biological resources.

Americas: Eleven of the 33 LAC countries have adopted regulations or legislation on ABS[41], 10 of these within the last decade, and Argentina, Chile, Dominican Republic, Ecuador, Guyana and Uruguay are drafting such regulations. Canada adopted guiding principles on access and benefit sharing policies in 2002[42]. In 1996, the Andean Community countries adopted Decision 391 on a common regime on access to genetic resources. Central American countries have also drafted an Agreement for access to genetic and biochemical resources and related traditional knowledge.

Asia and the Pacific: Bangladesh, Bhutan, China, India, Indonesia, Republic of Korea, Philippines, Thailand, and Vanuatu all have measures in place to regulate access to genetic resources, either in specific legislation or within legislation that is broader in scope. Malaysia, Nepal, New Zealand and Sri Lanka are currently drafting legislation on ABS whereas Australia, for which these issues are determined largely at the state level, is seeking to ensure that there is a consistent approach nationally. In 2000, the ASEAN countries established a framework agreement regarding access to biological and genetic resources.

Europe: Ten countries, Albania, Bulgaria, Czech Republic, Greece, Hungary, Italy, Former Yugoslav Republic of Macedonia, Portugal, Slovak Republic and Sweden have all adopted regulations or guidelines in the past decade concerning their genebanks and ABS, and Lithuania and Norway are in the process of doing so. In 1999, the CIS countries[43] signed an agreement on cooperation in the conservation and management of PGRFA, but a lack of funds limits its implementation. Portugal is the only European country to have adopted specific legislation on ABS under the CBD, while Italy has enacted legislation that defines measures to be taken to ensure the conservation of PGRFA and ABS[44]. In 2003, the Nordic Council of Ministers that includes Denmark, Finland, Iceland, Norway, Sweden and the autonomous territories of the Faroe Islands, Greenland and Åland, adopted the Nordic Ministerial Declaration on Access and Rights to Genetic Resources.[45]

Near East: Afghanistan, Egypt, Malta and Turkey have all put in place regulations regarding their national genebanks and access to their genetic resources. The development of a law governing access and exchange of genetic resources is at an advanced stage in Syria while draft legislation is under development in Jordan, Lebanon, Morocco and Pakistan.[46]

Box 7.4 Implementing the Multilateral System through administrative measures – The German experience

In Germany the responsibility for PGRFA is shared between the Federal and Laender authorities, and PGRFA is also held in private institutions. The focal point for the ITPGRFA is the Federal Ministry of Agriculture. The framework for the implementation of the Multilateral System, including activities of both governmental and private institutions, is provided by the **National Programme** on Plant Genetic Resources of Agricultural and Horticultural Crops, by the **Advisory and Co-coordinating Committee** for Agricultural and Horticultural Crops, and by the **National Inventory** for Plant Genetic Resources.

As a **first step** in implementation of the Multilateral System in Germany, information on the System was provided to all relevant stakeholders, both in the public and the private sectors, including the preparation of explanatory notes on the SMTA and Frequently Asked Questions (FAQs). Public and private institutions have been informed of the SMTA and the rights and obligations arising from its use. The private sector has also been encouraged to make voluntary payments when a product that incorporates material accessed from the Multilateral System is commercialized without restrictions.

As a **second step**, existing collections of Annex 1 PGRFA were examined against the criteria of governmental 'management and control'. As a result of this examination,

- Collections under the direct control of the Federal Ministry were **instructed** to introduce the SMTA;
- Collections under the control of the Laender and/or local authorities were **requested** to introduce the SMTA;
- All other collections (mixed, private) were **invited** to introduce the SMTA.

In 2007, the SMTA was introduced by the German Fruit Genebank and the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK).[47]

The **third step** was the identification of Annex I material in the genebanks that are in the public domain, excluding both material held under black-box arrangements, for example, and protected varieties, which are available for further research and breeding from the individual breeders.

The **final step** was to include the identified material formally in the Multilateral System, and to identify such material in the databanks by an MLS flag.

As of April 2008, more than 108,000 accessions have been included in the Multilateral System by German institutions. The case study draws the following lessons from the German experience:

- Early and comprehensive information of the relevant stakeholders on the national implementation of the MLS and the SMTA by the respective authorities is important.
- Existing "infrastructure" for cooperation such as a National Programme for PGRFA with a National Coordination Committee and a National Inventory (documentation system) should be used as much as possible.
- The text of the SMTA is not self-explanatory, especially for users not speaking UN languages. There is a need for assistance through experts giving guidance and/or a courtesy translation in the national language. Explanatory notes, FAQs, etc. are useful in order to facilitate the implementation of the MLS and the SMTA at national level.
- General guidelines on how to include material in the MLS at the collection level (e.g., identification of public domain accessions) could be helpful.

Source: 'Implementation of the Multilateral System of the International Treaty on Plant Genetic Resources for Food and Agriculture – A German Case Study', prepared for the Second Technical Consultation on information Technology Support for the Implementation of the Multilateral System, Rome 2-3 December2008, FAO document IT/GB-3/TCIT-2/08/Inf.1

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[1] Article 13.6 requires the Governing Body to consider the modalities of a strategy of voluntary benefit-sharing contributions from the food processing industries benefiting from plant genetic resources for food and agriculture. No such scheme has yet been agreed.
[2] The term *sui generis* is used in the legal sense of an instrument that is designed for a specific purpose, in this case a legal instrument specifically designed to protect plant varieties
[3] International Convention for the Protection of New Varieties of Plants, 1961, as revised in 1972, 1978, and 1991 Article 5.2.
[4] CGRFA-11/07/Report
[5] For example Morocco, Nepal, Spain, Sri Lanka and Uruguay
[6] http://km.fao.org/gipb/
[7] Tomme Young: Legal Issues Regarding the International Regime: Objectives, Options and Outlook, pp. 271-293 in *Accessing Biodiversity and Sharing the Benefits: Lessons from Implementing the Convention on Biological Diversity*; ed. S. Carriosa, S. Brush, B. Wright, and P. McGuire, IUCN Environmental Policy and Law Paper No. 54, IUCN 2004.

[8] Some assistance is already being offered by FAO and Bioversity International under their Joint Programme of Assistance to countries who request it in the implementation of the International Treaty and its Multilateral System. See ftp://ftp.fao.org/ag/agp/planttreaty/noti/NCP_GB3_JIP1_e.pdf
[9] E.g. Acre State Law - Accesso a recursos genéticos lei estadual (1997) and Amapá State Law on Access to Genetic Resources (1997)
[10] http://www.norden.org/pub/miljo/jordogskov/sk/ANP2004745.pdf
[11] http://www.cbd.int/abs/measures.shtml
[12] Afghanistan, Argentina, Australia, Bhutan, Brazil, Bulgaria, Cameroon, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Ethiopia, Gambia, Guatemala, Guyana, India, Kenya, Malawi, Mexico, Nicaragua, Panama, Peru, The Philippines, Portugal, South Africa, Uganda, Vanuatu, Venezuela and Zimbabwe
[13] For example, country reports of Bhutan, Brazil, Bulgaria, Costa Rica, Ethiopia, Malawi and Philippines
[14] For example, the country reports of Afghanistan, Algeria, Albania, Armenia, Dominica, Dominican Republic, Fiji, Ghana, Jordan, Laos, Lebanon, Madagascar, Malawi, Malaysia, Mali, Morocco, Namibia, Nepal, Nigeria, Oman, Pakistan, Palau, Russian Federation, Tajikistan, Tanzania, Thailand, Trinidad & Tobago, Uruguay, Vietnam and Zambia
[15] Young, op. cit. p.275.
[16] For example, S. Laird and R. Wynberg (2008): Study on Access and Benefit-Sharing Arrangements in Specific Sectors, UNEP/CBD/WG-ABS/6/INF/4/Rev.1, document presented to the Sixth Meeting of the Ad Hoc Open-ended Working Group on Access and Benefit Sharing, Geneva, 21-25 January 2008.
[17] Law No. 27811 of August 2002, Articles 8 and 27 (c).
[18] Laird and Wynberg 2008, op. cit.
[19] Laird and Wynberg 2008, op cit. p. 19
[20] R. Andersen and T. Winge (2008): Success Stories from the Realization of Farmers' Rights Related to Plant Genetic Resources for Food and Agriculture, FNI Report 4/2008 (Lysaker, Norway: The Fridtjof Nansen Institute), page 31.
[21] African Model Legislation for the Protection of the Rights of Local Communities, Farmers and Breeders. and for the Regulation of Access to Biological Resources, OAU Model Law, Algeria, 2000 http://www.opbw.org/nat_imp/model_laws/oau-model-law.pdf
[22] Proclamation No. 482/2006 on Access to Genetic Resources and Community Knowledge, and Community Rights
[23] Law No. 27811 establishing the Protection Regime for Collective Knowledge of Indigenous Peoples Connected with Biological Resources, 2002
[24] Decree-Law No. 118/2002.
[25] e.g. COP decisions II/11 and III/15.
[26] The primary role of the Third Party Beneficiary is to initiate dispute-resolution proceedings under the SMTA where necessary to protect the interests of the Multilateral System. However the concept originally arose during the negotiations of the SMTA in part out of a concern by developing countries for an international mechanism to ensure compliance with the terms and conditions of the SMTA.
[27] 98/44/EC
[28] These include the 11 CGIAR Centres holding in trust collections, CATIE, the COGENT coconut collection for Africa and the Indian Ocean, the COGENT coconut collection for the South Pacific, and the Mutant Germplasm Repository of the FAO/IAEA Joint Division, Agreements are expected to be signed in the near future with the International Cocoa Genebank of the University of the West Indies, and the Secretariat of the Pacific Community (SPC).
[29] Notification from the Treaty Secretariat dated 11 June 2008 ftp://ftp.fao.org/ag/agp/planttreaty/noti/csl806e.pdf
[30] http://www.planttreaty.org/inclus_en.htm
[31] Review of the Implementation of the Multilateral System, FAO Doc. IT/GB-3/09/13
[32] For example the country reports of Germany and The Netherlands. The UK has also reportedly successfully encouraged government-supported institutions to place their collections in the Multilateral System.
[33] The First Consultation of Experts was convened by the Secretary of the Treaty in July 2008.
[34] Ethiopia, Proclamation No. 482/2006 on Access to Genetic Resources and Community Knowledge, and Community Rights, 2006, Article 15. The Proclamation provides for a Special Access Permit.
[35] Morocco, Sudan and Syria are examples.

[36] For an account of AEGIS see http://www.ecpgr. cgiar.org/AEGIS/AEGIS_home.htm
[37] Experience of the Centres of the Consultative Group on International Agricultural Research (CGIAR) with the implementation of the agreements with the Governing Body, with particular reference to the Standard Material Transfer Agreement, FAO Doc. IT/GB-2/07/Inf. 11.
[38] Experience of the International Agricultural Research Centres of the Consultative Group on International Agricultural Research with the Implementation of the Agreements with the Governing Body, with particular reference to the use of the Standard Material Transfer Agreement for Annex 1 and Non-Annex 1 Crops, FAO Doc. IT/GB-3/09/Inf.15.
[39] Review of the Implementation of the Multilateral System, FAO Doc. IT/GB-3/09/13
[40] FAO, 2009. Report of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture, Third Session. Tunis, Tunisia, 1-5 June 2009 IT/GB-3/09/Report
[41] Bolivia, Brazil, Colombia, Costa Rica, Cuba, Guatemala, Mexico, Nicaragua, Panama, Peru and Venezuela.
[42] http://www.cbd.int/doc/measures/abs/msr-abs-ca-en.pdf
[43] Albania, Belarus, Georgia, Moldova, Russia and Ukraine
[44] Law no. 46/2007 of April 6, 2007
[45] Resolution No. 862 of 2005 establishing the National Bank of Genes
[46] Resolution No. 862 of 2005 establishing the National Bank of Genes
[47] Article 13.6 requires the Governing Body to consider the modalities of a strategy of voluntary benefit-sharing contributions from the food processing industries benefiting from plant genetic resources for food and agriculture. No such scheme has yet been agreed.

Chapter 8

The contribution of PGRFA to food security and sustainable agricultural development

8.1 Introduction

Over recent decades, agriculture has undergone enormous changes as a result of both technological advances and changing human needs and desires. Whereas, on the one hand yields have increased dramatically through a combination of improved crop varieties, and a greater use of external inputs[1] and on the other hand there have been increasing demands on land for uses other than the production of food, as well as and growing concern about the sustainability and safety of some modern practices.

In spite of advances in food production, food insecurity is still widespread. The latest FAO figures indicate that in 2008 there were some 1.02 billion chronically hungry people in the world - an increase of about 200 million since the World Food Summit in 1996. It is estimated that the number of hungry people increased by over 100 million due to the food price crisis of 2007-2008 alone. Most of the worst affected people (about 75%) live in rural areas of developing countries and depend directly or indirectly on agriculture for a large part of their livelihoods. A 70% increase in world agricultural production over today's levels will be required to meet the food demands of the estimated 9.2 billion people in 2050.

In 2000, the United Nations Millennium Declaration was adopted, committing nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound targets - with a deadline of 2015 - that have become known as the Millennium Development Goals (MDGs) (see Box 8.1). All countries and all of the world's leading development institutions have agreed to these eight goals. The achievement of two of these, in particular, will require the conservation and use of PGRFA: the eradication of poverty and hunger, and the achievement of environmental sustainability.

The aim of this chapter is to discuss the role and contribution of PGRFA to food security, sustainable agriculture, economic development and poverty alleviation. The chapter will not review or interpret these four concepts or their inherent complexity and inter-linkages. Instead, it will look at the role of PGRFA in the context of some of the emerging and difficult challenges now facing agriculture. Unlike the other seven chapters, this one does not have a counterpart in the first SoW report and so there is no baseline upon which to build. It thus aims to provide an overall review of the current status of PGRFA in relation to sustainable agriculture, food security and economic development and concludes with a summary of some of the main changes that have occurred in recent years and identifies some of the key gaps and needs for the future.

8.2 Sustainable Agriculture Development and PGRFA

Since the UNCED Conference in 1992 and the subsequent WSSD in 2002, sustainable development has grown from being a concept focusing mainly on environmental concerns, to a widely recognized framework that attempts to balance economic, social, environmental and inter-generational concerns in decision-making and action at all levels.[2]

The sustainability of agricultural systems is extremely important within the context of overall sustainable development and there are many concerns about the non-sustainability of many agricultural practices: the over-use or misuse of agrochemicals, water, fossil fuels and other inputs, soil erosion, the shifting of production to more marginal land, encroachment into forested areas and the like. The MEA[3] undertaken between 2001 and 2005 reported that about 60% of the ecosystems studied were being degraded or used unsustainably, while the demands of a continually expanding human population, climate change and increasing demand for biofuels are all putting additional and new pressure on land. The wise use of agricultural biodiversity in general, and PGRFA in particular, offers a way forward on many of these inter-related issues. The following sections look at two aspects of this: the role of genetic diversity in sustainable agriculture and the role of PGRFA in the provision of ecosystem services.

8.2.1 Genetic diversity for sustainable agriculture

Plant genetic resources are a strategic resource and a tool for sustainable agriculture. The link between genetic diversity and sustainability has two main dimensions: firstly the deployment of different crops and varieties, and the use of genetically heterogeneous varieties and populations, can be adopted as a mechanism to reduce risk and increase overall production stability; and secondly, genetic diversity is the basis on which new crop varieties can be bred to meet a variety of challenges.

Many country reports have expressed concern about the increasing use of genetically uniform varieties and the trend for them to be grown on ever expanding areas, resulting in increased genetic vulnerability (see Chapter 1.3). The countries called for a greater use of genetic diversity to counter this. The deployment of diversity at the farm and field level helps provide a buffer against the spread of new pests and diseases and the vagaries of weather. In the case of pests and diseases, for example, while some individual component might be susceptible, there is a strong possibility that other components will be partially or totally resistant or tolerant. In such situations, not only will the resistant or tolerant component produce some yield, thus avoiding total crop failure, but there is also good evidence that in many circumstances such genetic diversity can also significantly slow the overall rate of spread of a disease or pest. Thus production strategies that include the deployment of diversity are likely to be more stable overall than monocultures of uniform varieties, to have a reduced risk of crop failure and require fewer pesticides. There is also evidence that in cases where heterogeneous varieties are able to exploit a given environment more efficiently and effectively, this can result in higher and more stable yields.

The development and production of appropriate crop varieties provides one of best mechanisms for addressing many of the most important agricultural challenges related to sustainability. Varieties that are pest and disease resistant require fewer fungicide and insecticide applications; varieties that compete better with weeds require less herbicide; varieties that use water more efficiently can produce higher yields with less water; and varieties that use nitrogen more efficiently require less nitrogenous fertilizer, with a concomitant saving in fossil fuel. While varieties already exist having many of these characteristics, the situation is far from static. Agricultural environments change as do farming systems; new pests and diseases arise and the demand for specific products is constantly shifting. The result is that there is a continual need for new varieties. A variety that performs well in one location may not do so in another and a variety that produces a good yield this year may be knocked out by a new pest the following year. In order to be able to continually adapt agriculture to ever changing conditions, plant breeders will need to develop and maintain a pipeline of new varieties. Genetic diversity underpins the whole process of producing new varieties; it is the reservoir that enables breeders to keep the pipeline full.

The country reports cite several examples of the use of PGRFA to improve pest and disease resistance. In Pakistan, for example, 2 million cotton bales were lost from 1991 to 1993 due to a crop failure caused by Cotton Leaf Curl Virus. Resistant cotton types were subsequently identified and were used to develop new virus resistant cotton varieties, adapted to the growing conditions in Pakistan[4]. Morocco was able to release the first Hessian fly resistant durum wheat varieties, derived from inter-specific crosses with wild relatives.[5] There are countless such examples and all depend on the existence of PGRFA and the ability to access and utilize it. While genetic diversity represents a 'treasure chest' of potentially valuable traits, as shown elsewhere in this document, it is, however, under threat and special efforts are needed to conserve it both *in situ* (see Chapter 2) and *ex situ* (see Chapter 3), as well as to develop country capacity - especially in the developing world - to utilize it (see Chapter 4).

8.2.2 Ecosystem services and PGRFA

Agriculture contributes to development not only as an economic activity and as a source of livelihoods, but is also an important provider of environmental services.

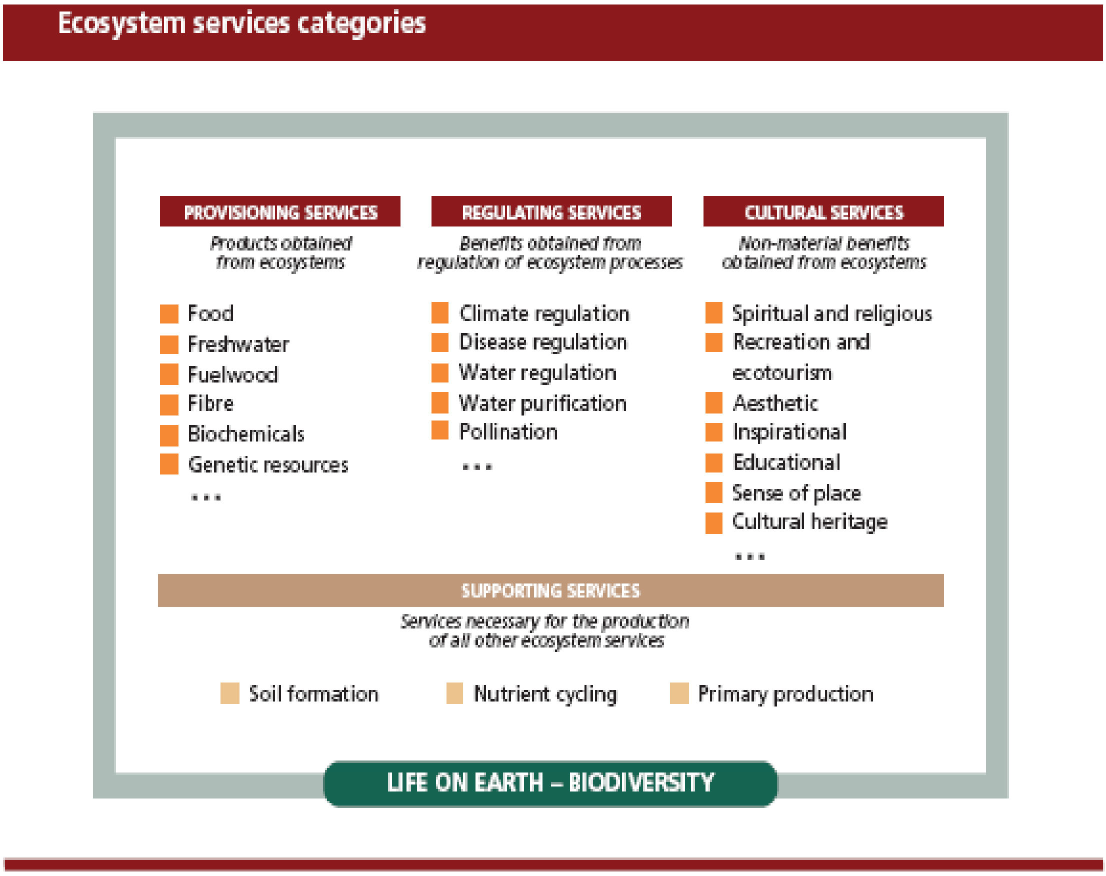
Figure 1[6] illustrated the four broad categories of services provided by ecosystems. These include:

- Provisioning services: the supply of products from ecosystems, such as food, and genetic resources;
- Regulating services: the benefits, such as water purification obtained from the regulation of ecosystem processes;
- Cultural services: non-material benefits obtained from ecosystems such as recreation, education and ecotourism; and
- Supporting services: the services needed for the production of all other ecosystem services. These include such things as nutrient recycling and soil formation.

PGRFA plays an important role in all four categories. In addition to being a direct 'provisioning service', genetic resources underpin the production of more and better food, either directly or through providing feed for livestock. They are also important as the basis for improving fibre and fuel production by crops. Carbon sequestration by crops - for example deep-rooted rangeland species - can help regulate climates and control water run-off, and PGRFA is intimately bound up with pollination, all of which are key aspects of 'regulating services'. In the area of 'cultural services', the diversity of traditional crops and foods can be an important feature of ecotourism; and as a 'supporting service' PGRFA can underpin the development of new varieties, for example of food and forage legumes, having an enhanced ability to recycle nutrients such as nitrogen within an agroecosystem.

In recent years many programmes have been initiated that seek enhance these services, in particular through rewarding those responsible for managing the underlying resource through Payment for Ecosystem Services (PES) schemes. However, implementing PES is a challenge, as are many of the services arise from complex processes, making it difficult to detemine which actions affect their provision, who is responsible for these actions and who are the beneficiaries who should pay for them. For instance, if, for example, on farm conservation of a particular traditional crop variety is considered eligible for PES, the challenge is to determine which farmer or farmers should be compensated for its conservation, how much should they receive, for how long, who should pay and what mechanisms are in place for monitoring and ensuring that payments are actually made and t6hat the service is actually provided. This dilemma lies at the heart of much of the debate over how to implement Farmers Rights (see Chapter 5 and 7). Nevertheless, PES raises hopes and expectations for the development of a more environmentally friendly agriculture and the PGRFA sector has a critical role and a responsibility to be part of the debate and action.

Figure 8.1 Categories of Ecosystem Services



Source: Adapted from *Ecosystems and human well-being: a framework for assessment* by the Millennium Ecosystem Assessment. Copyright © 2003 World Resources Institute. Reproduced by permission of Island Press, Washington, DC.

8.3 PGRFA and Food Security

Food security and the surrounding issues were put firmly on the global agenda in the Rome Declaration on World Food Security in 1996, which called for ‘the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger.’ Later, in 2002, the World Food Summit: Five Years Later led to the development of ‘Voluntary Guidelines to support the progressive realization of the right to adequate food in the context of national food security’.[7] These guidelines were adopted by the 127th Session of the FAO Council in 2004.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are: availability, stability of supply, access and utilization.[8] The PGRFA sector has multiple roles to play in ensuring food security, for example: producing more and better food for rural and urban consumers; providing healthy and more nutritious food; and enhancing income generation and rural development.

8.3.1 Crop production, yields and PGRFA

Agricultural production in general, and crop production in particular, must increase substantially in order to meet the rising food demands of a population that is projected to expand by some 40 percent over the period from 2005-07 to 2050. According to one projection by FAO, an additional billion tonnes of cereals will be needed annually by 2050.[5] Since on average, only 16 percent[9] (15 percent of cereals and 12 percent of meat) of the world's agricultural production enters international trade[5], much of the increase will have to be met through expanding production within those primarily developing countries that experience the greatest increase in demand.

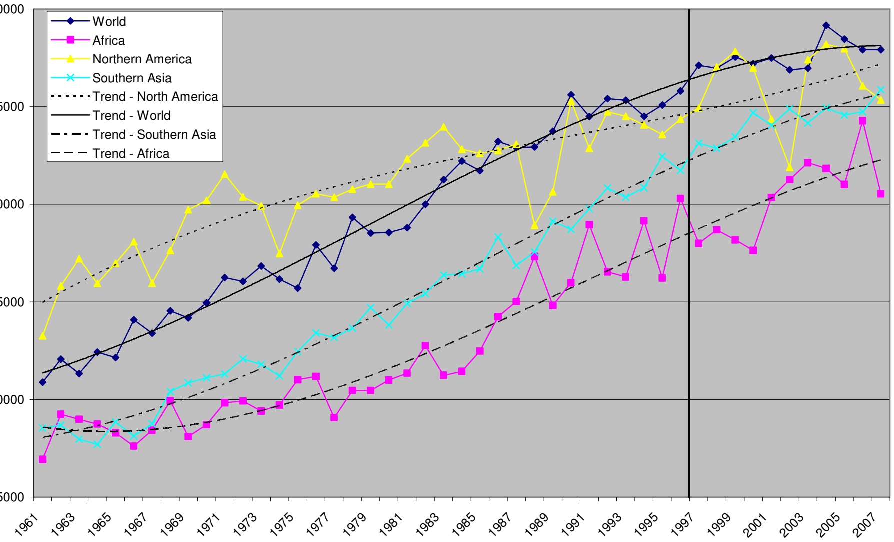
Many country reports from all regions have documented the unequivocal role of sound management of PGRFA in strengthening national food security. In China, for example, varieties of rice, cotton and oil seed crops have all been replaced 4 to 6 times throughout the country since 1978, each replacement representing the introduction of a new variety that was an improvement over the one it replaced. This resulted in yield increases of 10% and more associated with each replacement, and with every 10% yield increase, the level of poverty has been reduced by 6 to 8%.[10] According to the Malawi country report, adoption of improved varieties of sorghum and cassava has led to higher yields and greater food security at both the household and national level. The increased use of improved varieties has also opened up business opportunities for farmers and the extra income derived from marketing cash crops and value added products such as cassava snacks has, over time, helped to boost local industry, led to the fabrication of local cassava processing equipment, increased the use of cassava in livestock feed and provided funds for the development of local on-farm seed programmes.[11]

Recent experience with crop productivity growth gives reason for both optimism and concern. When growth in yield-per-hectare has been assessed for key staple crops over the past several decades, it is apparent, particularly for wheat, that productivity growth has levelled off in recent years (see Figure 8.3). Maize and rice productivity have continued to increase on a world scale in recent years, although rice yield increases have also levelled off in East and Southeast Asia. In Africa, yields of all three crops are still far below those typically seen in other regions. Much of the yield increase is attributable to a combination of factors including an increased use of appropriate inputs and good weather conditions. However, one key factor has undoubtedly been the development and dissemination of improved crop varieties.

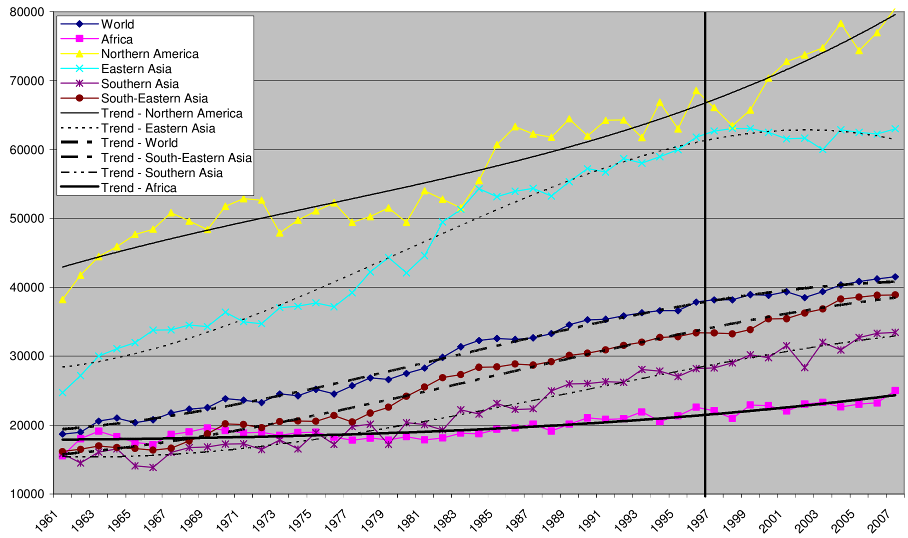
The production of staple food crops remains the largest agricultural sub-sector in most countries and will continue to play an important role in meeting food security and agricultural development objectives in the future. Sustaining productivity growth in 'breadbasket' zones, where new, high-yielding varieties and associated practices have already been widely adopted, will remain an important strategy for meeting future food needs, particularly for rapidly growing urban populations. This will require a continued stream of new varieties to meet the changing needs and environments in these 'breadbasket' areas. A significant share of the increase in staple foods will also have to come from more marginal environments, home to many of the world's poorest people and a pipeline of new varieties will be needed for these areas too.

Figure 8.2 Average yields (hg/ha) for a) wheat, b) paddy rice, and c) maize by major regions: 1961-2007 (The vertical bar marks the date at which the first SoW report was published)

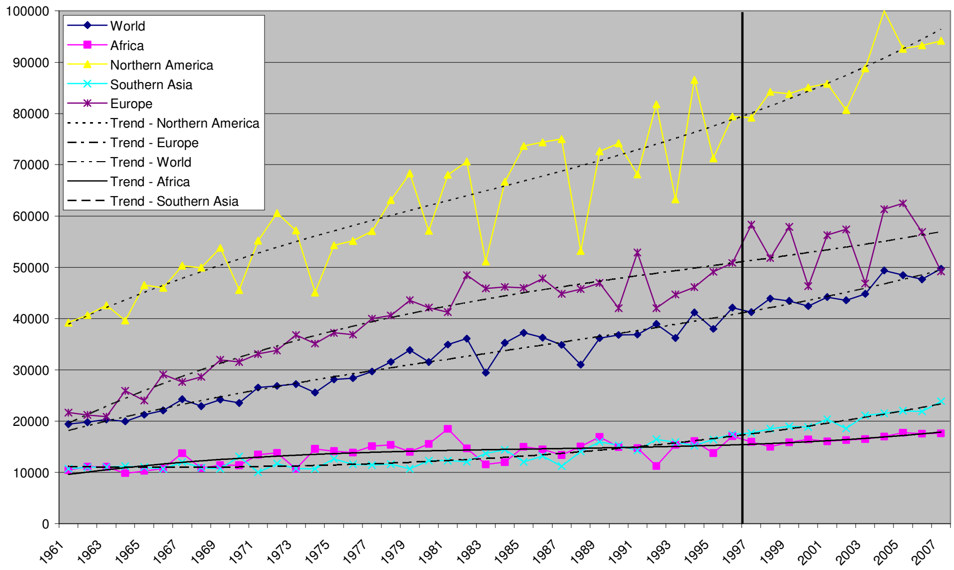
a) Wheat



b) Paddy rice



c) Maze



Source Faostat (http://faostat.fao.org)

8.3.2 Use of local and indigenous PGRFA

For many agrarian countries, the widespread use of locally adapted and indigenous PGR is a key part of local food security strategies. Farmers are familiar with growing traditional local varieties that are adapted to local environmental conditions, fit in with local farming systems, and meet local taste and other preferences: moreover, their diversity brings greater stability to overall production. Local varieties may also command special prices in niche markets and for agrotourism. There are many examples to illustrate this in the country reports and in other publications. In lowland areas of Vietnam, for example, many traditional varieties are maintained because of their adaptation to local climate, soils and other conditions and are appreciated for their cultural value, productivity, taste and cooking qualities.[12] An analysis of maize landraces in Mexico[13] found that even though new, high yielding varieties were available and supported by the government, farmers maintained complex populations of landraces in order to satisfy their main concerns: coping with the effects of environmental heterogeneity, resistance to pests and diseases, cultural and ritual needs, and dietary and food preferences. There are a number of programmes, such as the “Programa Nacional do Desenvolvimento Rural do Continente” of Portugal,[14] that support on farm conservation of PGRFA, promote the use of local varieties and build on local and indigenous knowledge to add value. Latin America, has reported several programmes[15] that link small farmers and indigenous communities with governmental agricultural research institutions and genebanks to carry out joint activities on collecting PGRFA, on farm conservation, reintroduction, evaluation and participatory breeding.

Niche markets for regional and local products have expanded and with them the role and importance of the PGRFA of local crops has also grown. One example is the international Slow Food movement, which has had a significant impact in raising awareness as to the role of traditional food in local culture, the nutritional value of many local foods, the importance of dietary diversity and the need to reduce ‘food miles’. Several international initiatives have also supported this trend, such as the growth of ‘fair trade’ systems and the increasing use of ‘geographical indications’ to designate the specific geographical origin of a food item possessing qualities or a reputation that are strictly related to that place of origin.[16]

Finally, organic crop production, requiring varieties that are well adapted to organic growing conditions, has gained in importance globally, and is sometimes directly associated with the initiatives aimed at promoting traditional and local food such as described above.

8.3.3 Managing climate change with PGRFA

While the effects of climate change are only now beginning to be felt, there is a growing consensus that unless drastic measures are taken its future impact could be of vast proportions. Prediction models of the International Panel on Climate Change[17] as well as other reports[18] indicate that there will be severe effects on agricultural productivity in several parts of the world. The news is not all bad, however; some regions, especially those further away from the equator, are expected to have longer growing seasons and become more productive. Nevertheless, there remains very considerable cause for concern, especially for productivity in many tropical and sub-tropical regions that are least able to cope, such as in parts of southern Africa.[19] In many regions adaptation will require a shift to more drought-tolerant or heat-tolerant varieties or even a shift to other crops. Increased spread or shifts in pest and disease patterns seem to be taking place already, and new resistant or tolerant varieties will be needed, in order to maintain productivity. Less predictable weather patterns may also require the development of new varieties that are adapted to a wider range of more extreme conditions.

Overall the effects of climate change are likely to make it considerably more difficult to meet the increased demand for food, and the challenge will be exacerbated by competition for land for other uses, such as urban development or for growing new crops such as those for biofuel. Although bioenergy crops were hardly mentioned in the country reports, there have been significant moves to increase the production of biofuels in many countries, in response to growing concerns about climate change and in the face of fossil fuel scarcity. Aside from the potential food security implications of such large-scale landuse shifts, there is also concern that it could result in the loss of local crop varieties and bring pressure for crop production to spread into forests and other environmentally sensitive areas.

Several country reports refer to climate change and its potential impact on food production and genetic erosion, and the consequent need for greater efforts to conserve genetic diversity. Although there is no quantitative data provided, climate change emerges as a major concern across all regions

8.3.4 Gender dimensions of PGRFA

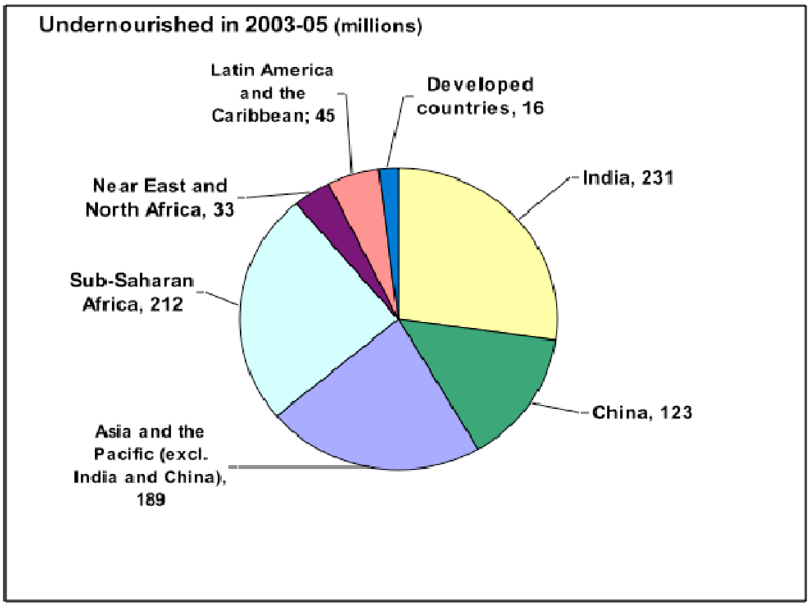
Gender is an important determinant of the extent and nature of the diversity of crops and varieties grown and is a key aspect of sustainable crop production and food security. Rural women are responsible for half of the world's food production and produce between 60 and 80% of the food in many developing countries. Women often have a particular responsibility for managing home gardens, and these tend to include a wider variety of vegetable, fruit, spices, medicinal, and other crops than is generally the case for fields producing staple-crops and for which men often have a primary responsibility.[20] Gender differences are further evident in varietal choices and the importance placed on different traits. Research in Tanzania, for example, showed differences between male and female farmers in the different importance and ranking they gave to various traits in sorghum.[21]

While overall this did not come across clearly in the country reports, it is critical that the role of rural women be better understood and taken into account in all relevant PGRFA initiatives.

8.3.5 Nutrition, health and PGRFA

The majority of food-insecure and undernourished people live in rural areas. They are most numerous in Asia and Sub-Saharan Africa. Seven countries comprising India, China, Democratic Republic of Congo, Bangladesh, Indonesia, Pakistan, and Ethiopia account for 65% of the world's food insecure people (see Figure 8.2).

Figure 8.3 Number of undernourished people in the world, 2003-2005 (millions)



Source:

PGRFA underpins not only total food production but also nutritional wellbeing (see Chapter 4.9.4). The best insurance against nutrient deficiencies is through eating a varied diet, thereby ensuring an adequate intake of all the macro and micronutrients needed for good health. However, many poor people do not have access to, or are unable to afford, an adequately diverse diet and have to rely heavily on just a few staple food crops for most of their food. In recognition of this, a number of breeding efforts are underway to improve the nutritional quality of staple crops, for example by producing rice, maize, cassava and sweet potato with higher levels of beta–carotene (the precursor of vitamin A), pearl millet and beans with higher levels of available iron, and rice, wheat and beans with higher levels of zinc.[22]

In addition to the important direct relationship between PGRFA, nutrition and human health, there are various indirect effects. For example, for resource poor populations in countries faced with the problems of HIV/AIDS, the consumption of diverse diets represents an important way of boosting human resistance and tolerance.

Plants are also extremely important for providing medicine and, their current production as well as future improvement is dependent on their genetic diversity. In some African and Asian countries, up to 80% of the population depends on traditional, mainly herbal, medicine. In Kenya, for example, a recent World Bank study indicated that 70% of the population is not covered by the national healthcare system and depend on traditional forms of medication.[23] Herbal medicines are highly lucrative: annual revenues in Western Europe reached US$ 5 billion in 2003-2004, in China sales totalled US$ 14 billion in 2005 and revenues of US$ 160 million were generated from herbal medicines in Brazil in 2007.[24]

8.3.6 Role of underused and neglected PGRFA

Since the first SoW report was published, many studies have documented the importance of neglected and under-utilized species for the food security and income of local communities (see Chapter 4.9.2). By definition, the area sown to these crops is relatively small worldwide;[25] there are few marketing opportunities and relatively little effort at crop improvement. Nevertheless country reports from all regions have described the role and uses of different species, ranging from those that are important for dietary diversity or have the potential to make a greater contribution to generating income, to those that are likely to become more important in local farming systems as climates gradually change.[26] They emphasise the importance of many of these species in the social and cultural fabric of local societies and call for increased efforts to conserve and utilize them. Many countries have reported efforts made over the past decade to collect, characterize, evaluate, and conserve samples of under-utilized species in their national plant germplasm systems[27] as well as efforts to promote and market them.[28]

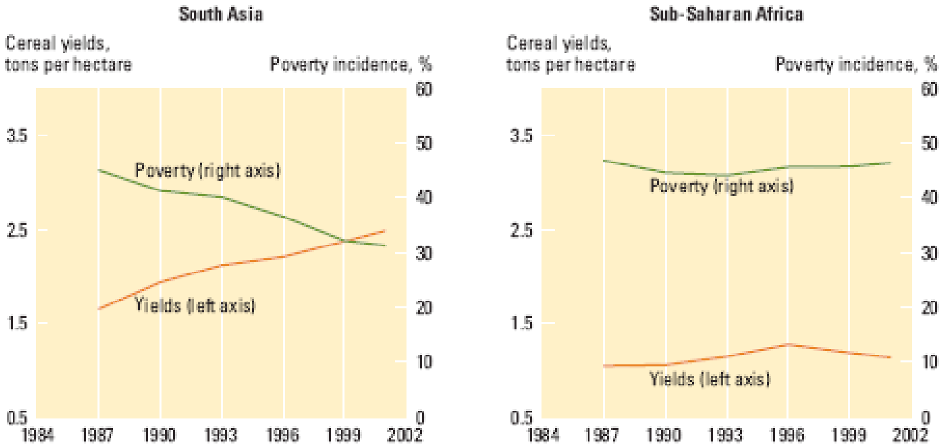
While much has been done in this area, much more still needs to be done and the efforts of institutions such as Crops for the Future (see Chapter 6.3.3)[29] can make a very valuable contribution to ensuring that neglected and under-utilized crops play a greater role in sustainable agriculture and livelihood systems in the future.

8.4 Economic Development, Poverty and PGRFA

The economic health and prosperity of a country depends on a large number of factors of which agricultural productivity and growth is one. The importance of agriculture varies by region, from only 1.9% of the population dependent on agriculture in North America to over 50% in Africa and Asia. However, taken overall, agricultural production is the main source of income for about half of the world's population. The choice of crops, varieties, planting material and associated production methods have a significant influence on productivity and livelihoods. Generally, farmers grow a number of different crops and varieties, each of which provides a set of benefits in the form of income, food, and other products. In addition, benefits may arise from the overall portfolio of crops and varieties, including mitigation against the effects of failure of any one crop or variety, spreading production through the year and achieving a greater intensity of land use.

Marketed values vary by crop, variety and marketing channel. In many countries the growth of a dynamic food-marketing sector has created high-value potential market outlets, representing an important means of increasing farm incomes and achieving food security. Several studies have indicated that agricultural productivity growth has had an important effect on poverty reduction[30] and plant breeding has played a predominant role in this. Nonetheless, while this is certainly the case for Asia and Latin America, the relationship is less clear in Sub-Saharan Africa where agricultural yields have generally stagnated, making it more difficult to clearly establish a relationship with poverty reduction (see Figure 8.4).

Figure 8.4 Relationship between cereal yield and poverty in South Asia and Sub-Saharan Africa



Sources: Ravallion and Chen 2004; World Bank 2006y.

Many small farmers experience difficulties in accessing both input and output markets and several country reports indicated that this is one of the most serious constraints to diversifying crop production. Lack of access to good quality seed of appropriate varieties can prevent farmers from entering specific markets. Numerous country reports, particularly from Africa, referred to the sub-optimal state of seed production and distribution systems, noting widespread problems with insufficient availability of new and appropriate varieties of seed. Overcoming input and output bottlenecks and inequalities in the value chain is a key strategy for increasing the market value of crops – and one that has important implications for the management of PGRFA.

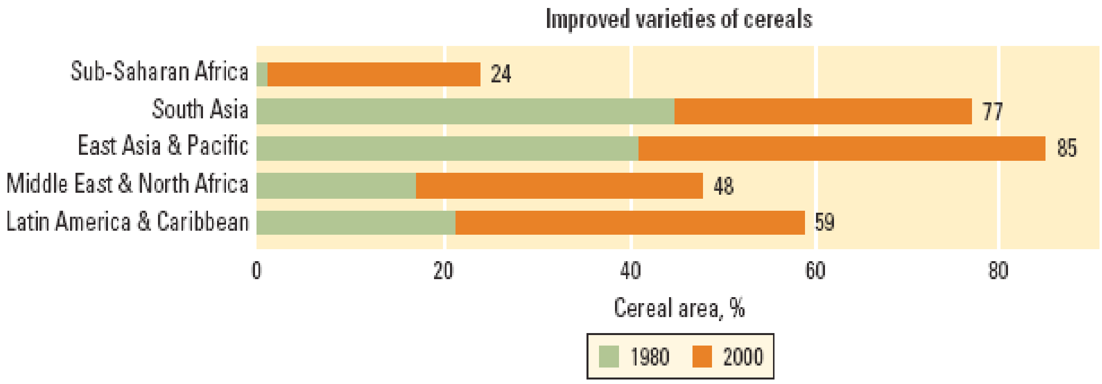
While sound crop management (along with land and water management) is critical for success, it is very difficult to place an exact economic value on the underlying genetic resources. Estimating the value of PGRFA by rigorous economic methods summing their direct use, indirect use, option and non-use values underestimates their overall value.[31] This problem hampers efforts to make a case for investing more in PGRFA and is a significant impediment to securing adequate funding for genebanks. However, some of the most convincing data come from impact studies based on tracing germplasm flows. In one study,[32] for example, it was estimated that conserving 1,000 accessions of rice generates an annual income stream for developing countries with a direct use value of $325 million at a 10% discount rate. This calculation also served to highlight the need for better integration and linkages between conservation, plant breeding and seed delivery for realising the full potential of PGRFA.

8.4.1 Modern varieties and economic development

Overall the contribution of modern varieties to agricultural growth and poverty reduction has been very impressive.[33] The impact has been both direct and indirect: high yields generating higher incomes, but also generating employment opportunities and lower food prices.[34]

However, in a study across 11 food crops in four regions over the period 1964-2000,[35] it was concluded that the contribution of modern varieties to productivity increases was a 'global success, but for a number of countries a local failure.' Many of these countries are located in Sub-Saharan Africa where adoption of improved varieties of cereal crops was very low during initial phases of the Green Revolution, and only began to reach significant levels in the late 1990s (see Figure 8.5). It is interesting to note, in this respect, that the yield growth experienced by Sub-Saharan Africa, although relatively small, has been almost completely attributable to modern varieties, with little contribution from fertilizer and other inputs.[36]

Figure 8.5 The growth in area under improved cereal varieties in 1980 and 2000



There is considerable variability in adoption patterns of modern varieties within regions as well as across crops. In Latin America, for example, farmer-saved maize seed was grown by 60 to 100% of farmers in most Central American countries (with the exception of El Salvador) and by more than 50% of the farmers in Bolivia, Colombia, Peru, and Paraguay.[37] However, hybrid seed maize was more widely used in Argentina, Brazil, Ecuador, Uruguay and Venezuela. Similar patterns were evident in Eastern and Southern Africa, where the adoption of modern semi-dwarf varieties of wheat was high in most countries, but adoption of hybrid maize was far patchier (e.g. 91% adoption in Zimbabwe compared to 3% in Mozambique). Several factors help to explain these trends. One is environmental heterogeneity – e.g. in the harsh and variable highland regions of the Andes, local maize varieties may be better suited than improved hybrids. Another factor may be the availability of a large range of alternative types. Ethiopia, for example, which had lower levels of adoption of semi-dwarf wheat than other countries in the region, is a secondary centre of diversity for durum wheat, and thus greater genetic diversity was available to help farmers in their heterogeneous and difficult growing environments.

Studies at the household level paint a varied picture. Adoption tends to vary by crop rather than by household, and depends on such factors as the sources of seed and its cost, the specific agro-ecological conditions encountered and on the demands of the farm and consumption system. In an analysis of modern variety adoption of sorghum and bread wheat in low-income farming communities of Eastern Ethiopia[38] it was found that the poorest were significantly less likely to adopt modern varieties of either crop, although higher adoption levels were found for wheat than sorghum. Sorghum is a crop with considerable local diversity available through informal seed systems; it is grown for multiple purposes and where on farm seed-storage techniques are well developed. In contrast, bread wheat, unlike durum wheat, is a relatively recently introduced crop in this area of Ethiopia and as a result the genetic diversity available locally is quite limited.

While modern varieties contribute significantly to poverty reduction, they have arguably been less successful in sustainable agricultural development. Key shortcomings cited have been a lack of adaptation to heterogeneous and marginal production areas,[39] emphasis on wide rather than local adaptation and the failure, cited in several country reports, of many centralized plant breeding programs to breed for traits of concern to small-scale and resource poor farmers.

8.4.2 Diversification and the use of genetic diversity

The choice of which crops and varieties to plant is driven by a range of economic, social, and agronomic factors, including marketing outlets and prices, familiarity and societal acceptance, cost of production, need for and availability of production inputs (including seed or other planting material, water, fertilizer, pesticides, labour etc), climate, soils, and topography.

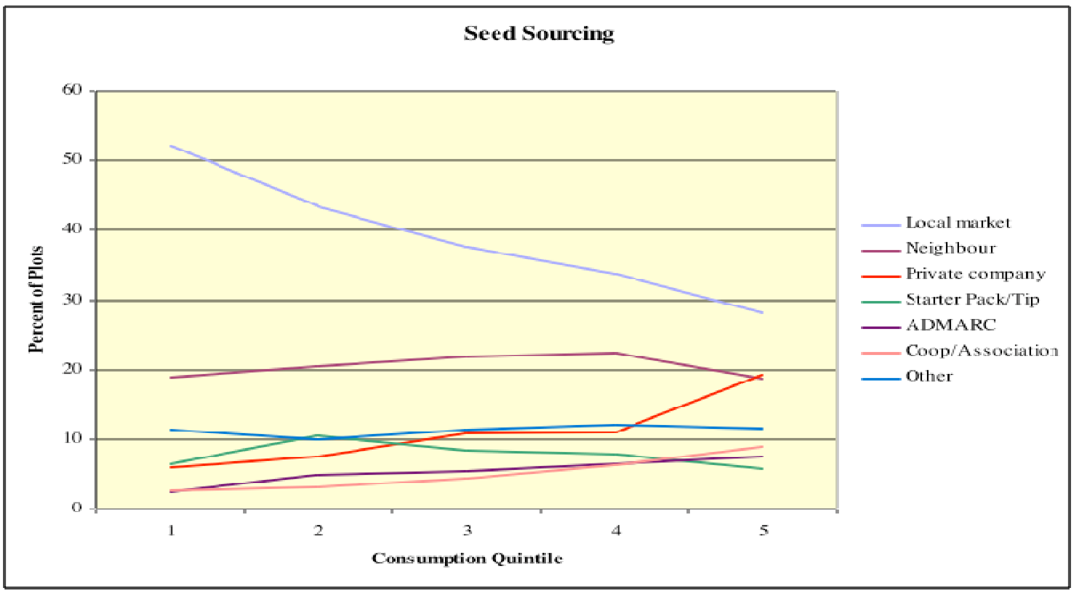
While for the more market-oriented producers varietal choice is largely driven by yield and market demand, this is not the case for most food-insecure farmers. Studies[40] have shown that household farms in most developing countries produce both for their own consumption as well as for sale,[41,42] and that when farmers are both consumers and producers of food, this has a major impact on what crops are grown.

Farm households also tend to draw on a variety of activities to attain food and income security and stability.[43] Diversification across activities is an important risk management strategy – often one of the very few available to poor farmers. At the crop level, farmers can diversify with respect to the crops and varieties they grow. At the farm level, a diversity of enterprises can be undertaken in addition to cropping, e.g. food processing, meat or egg production, agroforestry or agrotourism; and many of these have important implications for genetic diversity and the crops and varieties grown. Households are also increasingly relying on off-farm employment, often with one or more family members taking on paid employment away from the farm and remitting money back home. A recent study looked at data from the FAO Rural Income Generation Project (RIGA) across sixteen developing countries in Africa, Latin America, Asia, and Eastern Europe.[44] The study found that income diversification was generally the norm for most of the countries, although less so for those in Africa where off-farm opportunities are normally fewer. Different income diversification strategies, within and outside of agriculture, obviously have different implications for PGRFA management.

8.4.3 Access to seed

Chapter 4 emphasized how, for agriculture to be successful and sustainable, sufficient good quality seed has to be available to farmers at the right time and at the right price. Recent evidence underscores the importance of markets in providing seed to poor farmers.[45] Analysis of the FAO RIGA data for Malawi, Nigeria, and Ghana confirms this. In Malawi, for example, purchased seed was used on 30% of the plots, a percentage that was essentially the same across all income groups (see Figure 8.6). However, the source of purchased seed varied significantly. While local markets were the most important source of seed for all groups, their relative importance diminished as farmers' wealth status increased, and private companies played an increasingly important role in providing seeds to better-off farmers.

Figure 8.6 Seed sources by consumption group in Malawi (1=poor; 5=rich)



Farmers tend to favour local markets for purchasing seed because 1) locally traded seed is less expensive than seed from industry; and 2) there is a ready availability of locally adapted materials.[46] Many country reports stressed the need for stronger seed production and distribution systems as well as for greater harmonization between the commercial seed section and farmers' seed sectors.

8.4.4 Globalisation and PGRFA

Globalisation and trade liberalisation have increased substantially since the first SoW report was published, leading to rapid economic expansion in many but by no means all countries. Market opportunities have opened up for new products, with the result that the demand for particular crops and varieties has shifted. Many small-scale farming systems that were traditionally self reliant for seed have increasingly had both the resources and need to access new varieties. Moreover, a growing share of produce from the small-scale sector is now being offered for sale in local, national and even international markets. The privatization of breeding has continued (see Chapter 4) and the commercial plant breeding sector has become markedly more concentrated in the hands of fewer multinational companies.

In the first three months of 2008, international food prices of all major food commodities reached their highest level in nearly 30 years (see Box 8.2). This was the result of a number of factors including: poor harvests in several major producing countries, a marked decline in food stocks, high energy prices, subsidized production of bio-fuels, speculation on futures markets, the imposition of export restrictions and a lack of investment in the agricultural sector.[47] Although prices of agricultural commodities have come down since then, they remain volatile and as of mid 2009 food prices in the most vulnerable countries remain high, in some cases double what they were just two years before. This has thrown into reverse earlier progress towards achieving the first Millennium Development Goal of eradicating poverty and hunger.

While obviously there is no single and easy solution, the wise use of PGRFA, particularly to underpin the breeding of new varieties, can make a very significant contribution to increasing and stabilizing total food production, increasing energy efficiency and increasing incomes of many of the world's poorest people.

8.5 Changes since the first SoW Report was published

Since the first SoW report was published, a number of trends relating to food security and sustainable agriculture have become more visible and new issues have emerged. Those having the greatest implications for, and impact on, the conservation and use of PGRFA include:

- Sustainable development has grown from being a movement focusing mainly on environmental concerns, to a widely recognized framework that aims to balance economic, social, environmental and inter-generational concerns in decision-making and action at all levels;

- There have been growing efforts to strengthen the relationship between agriculture and the provision of ecosystem services. Schemes that promote Payment for Ecosystem Services (PES) - such as the *in situ* or on farm conservation of PGRFA - are being set up in an attempt to encourage and reward farmers and rural communities for their stewardship of the environment. However, the fair and effective implementation of such schemes remains a major challenge;

- Concerns about the potential impact of climate change have grown substantially over the past decade. Agriculture is both a source and a sink for atmospheric carbon. PGFRA are becoming recognised as being critically important for the development of farming systems that capture more carbon and emit fewer greenhouse gasses, and for underpinning the breeding of new varieties adapted to future environmental conditions;

- Strong consumer demand for cheap food has continued, resulting in a sustained focus on the development of more cost-efficient production systems. Multinational food companies have gained in influence and, especially in industrialized countries, food is increasingly being produced beyond national borders in order to keep prices low;

- A simultaneous trend has seen the share of so-called niche or high-value markets expand. In many countries, consumers are increasingly willing to pay higher prices for better quality or novel food, from sources they know and trust. Certification schemes such as 'fair trade', and 'organic' or 'protected designation of origin' (PDO) have been established to help ensure standards and provide reliable source information;

- In most developed countries, and in a growing number of developing countries, commercial food production is responsible for the supply of most food products to the majority of people. Crop varieties have been bred to meet the needs of high-input production systems, industrial processing and strict market standards. There has been an increasing disconnect between rural producers and the growing numbers of predominantly urban consumers;

- In many developing countries, incentives are provided for farmers to shift to more commercial agricultural systems. This is having a major impact on livelihood strategies, culture, and on the genetic resources managed by farmers. Initiatives in an increasing number of countries, such as the establishment of commodity exchanges in an increasing number of countries are also resulting in more farming communities being linked to world markets;[48]

- Organic agricultural production is receiving greater attention in response to increasing concerns by consumers regarding diet, health and the environment;

- In spite of the on-going controversy, genetically modified crops are being grown on an expanding area in a growing number of countries.

8.6 Gaps and Needs

Much progress has been made over recent years in linking the conservation and use of PGRFA with endeavours to increase food security and develop more sustainable agricultural systems. However, there are still many gaps in our knowledge and in the range of action required to improve the situation. Attention is needed, for example in the following areas:

- There is a need for more efficient, strategic and integrated approaches to the management of PGRFA at the national level. Stronger links are required between public and private institutions concerned with conservation, crop improvement and seed systems;

- In spite of the enormous contribution by PGFRA to global food security and sustainable agriculture, its role is not widely recognized or understood. Greater efforts are needed to estimate the full value of PGRFA and to bring this to the attention of policy makers and the general public so as to generate the resources needed to strengthen programmes for its conservation and use;

- Given the highly heterogeneous conditions prevailing in most of the more marginal production environments, and the expected shifts and increase in variability due to climate change, it is critically important that farmers and plant breeders have ready access to the wide range of genetic diversity needed, so as to be able to adapt crops to the new conditions. While progress has been made in facilitating access, more is needed;

- Plant breeding efforts need to be strengthened to ensure the availability of a wider diversity of improved varieties for a larger range of crops, across more environments and at a readily affordable price;

- More genetic enhancement programmes to broaden the genetic base of new varieties are needed as a way to achieve greater resilience and reduce genetic vulnerability;

- Greater attention needs to be given to the development of more decentralized, participatory and gender sensitive approaches to plant breeding in order to more effectively generate varieties that are specifically adapted to the particular production environments and socio-economic situations of the poor in less favoured environments;

- Agricultural markets play a vital role in helping achieve food security and sustainable agricultural development. They can help increase the diversity of PGRFA in the seed supply chain and provide outlets for niche products. Better access by resource poor farmers to markets and strengthened market information systems are needed;

- There is a need for more accurate and reliable measures, standards, indicators and baseline data for sustainability and food security that will enable a better monitoring and assessment of the progress made in these areas. Of particular need are standards and indicators that will enable the monitoring of the specific role played by PGRFA.

Box 8.1 Millennium Development Goals

1. Eradicate poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environment sustainability
8. Develop a global partnership for development.

Box 8.2 FAO Initiative on Soaring Food Prices

FAO launched the Initiative on Soaring Food Prices (ISFP) in 2007 with the immediate goal of raising USD 1.7bn for rapidly increasing food production during the 2008 and 2009 agricultural seasons, mainly through supporting direct access to inputs for smallholders in the most affected countries. FAO's assistance has taken the form of:

(i) Interventions to increase access by small-scale farmers to inputs (e.g. seeds, fertilizer, animal feed) and improve agricultural practices (e.g. water and soil management, reduction of post-harvest losses);
(ii) Policy and technical support
(iii) Measures addressing smallholder access to markets; and
(iv) A strategic response to cushion the effects of rising food prices in the short, medium and long term, through increased and sustainable investment in agriculture

[1] FAO /CSD document
[2] WSSD Con 2002
[3] Millennium Ecosystem Assessment, (2005), Ecosystems and Human Well-being: Synthesis, Island Press, Washington, DC.
[4] Country Report, Pakistan
[5] Regional Synthesis NENA region
[6] FAO, 2007. The State of Food and Agriculture 2007. Part I: Paying farmers for environmental services. Rome.
[7] Right to Food Voluntary Guidelines
[8] FAO, 2001, The State of Food Insecurity in the World, Rome.
[9] Measured as (gross imports + gross exports) / 2 * production.
[10] Country Report, China
[11] Country Report, Malawi
[12] Nguyen Thi Ngoc Hue 2005
[13] Bellon, M. R., 1996, The dynamics of crop infraspecific diversity: A conceptual framework at the farmer level, Economic Botany, 50(1), 26–39.
[14] Country Report, Portugal
[15] Regional Synthesis Latin America
[16] See, for example, http://www.origin-gi.com
[17] http://www.ipcc.ch/
[18] For example: Burke, M.B., D.B. Lobell and L. Guarino, 2009. Shifts in African crop climates by 2050, and the implications for crop improvement and genetic resources conservation. Global Environmental Change. http://dx.doi.org/10.1016/j.gloenvcha.2009.04.003.
[19]Lobell, D.B. M.B. Burke, C. Tebaldi, M.D. Mastrandrea, W.P. Falcon and R.L. Naylor, 2008. Prioritizing Climate Change Adaptation Needs for Food Security in 2030. Science, Vol. 319. no. 5863, pp. 607 – 610.
[20] In some cases women are associated with particular crops. For example, in parts of Ghana, women are considered primarily responsible for providing ingredients for soups (considered a “female” dish), whereas men are responsible for providing starches (a “male” dish).
[21] FAO Links Project, data source: 2003.
[22] For example, http://www.harvestplus.org
[23] Country Report, Kenya
[24] For example, http://www.who.int/mediacentre/en/
[25] Padulosi S., Hodgkin T., Williams J.T. and Haq N., 2002, Underutilised Crops: Trends, Challenges and Opportunities in the 21st Century. In: Engels J.M.M., Ramanatha Rao V., Brown A.H.D. and Jackson M.T., (Eds), Managing Plant Genetic Diversity, 30: 323-338, IPGRI, Rome.
[26] Country Reports, China, Romania, Sri Lanka, Uganda, Yemen, Azerbaijan, Dominica, Jamaica, Malawi, and Zimbabwe, Bangladesh, Ethiopia, Georgia, India, Indonesia, Malawi, Pakistan, and Uganda Dominica, Malawi, and Zambia
[27] Country Reports, Ghana, Hungary, India, Pakistan, and Yemen
[28] Country Reports, Argentina, Bolivia, Costa Rica, Cuba, Dominican Republic, Ecuador, Jamaica, Palau, St. Vincent, and Zimbabwe.
[29] Crops for the Future was created in 2008 as a result of a merger between the International Centre for Underutilized Crops and the Global Facilitation Unit for Underutilized Species. www.cropsforthefuture.org/
[30] Thirtle C., Lin L., and Piesse J., 2003. The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia, and Latin America. World Development, 31 (12): 1959–1975
[31] Smale & Koo 2003
[32] Evenson & Gollin 1997
[33]Hazell, P.B.R., 2008. An Assessment of the Impact of Agricultural Research in South Asia since the Green Revolution, Science Council Secretariat: Rome, Italy.
[34]Gollin, D., Morris, M., and Byerlee, D., 2005. Technology Adoption in Intensive Post-Green Revolution Systems, American Journal of Agricultural Economics, vol. 87(5): 1310-1316
[35] Evenson, R.E., Gollin, D., (eds.), 2003. Crop Variety Improvement and Its Effect on Productivity: The Impact of International Agricultural Research, Wallingford , UK : CABI.
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[44] Winters, P., Davis, B., Carletto, G,. Covarrubias, K., Quinones, E., Zezza, A., Stamoulis, K., Bonomi, G., and Di Giuseppe, S., 2009. A Cross Country Comparison of Rural Income Generating Activities, *World Development*, forthcoming.

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[47] http://www.fao.org/worldfoodsituation/isfp/en

[48] GabreMadhin, E.Z. and I. Goggin, 2006. Does Ethiopia need a commodity exchange? An integrated approach to market development. ESSP Policy Conference Brief No. 14 - http://www.ifpri.org/events/conferences/2006/ESSP06/gabremadhin1br.pdf

Annex 5.1

Status by country of national legislation and membership to international treaties and conventions related to PGRFA

Legend:

X	Existing legislation before 1996
X (shaded)	Existing legislation after 1996
O	Draft legislation
P	Party to the treaty or convention before 1996
P (shaded)	Party to the treaty or convention since 1996
S	Signatory of the treaty or convention before 1996
S (shaded)	Signatory of the treaty or convention since 1996

For UPOV, the latest Act to which the country adhered is indicated. However the colour of the case indicated whether the country joined UPOV before or after 1996, and not the date on which the country adhered to the latest Act.

Countries for which there is no information are not listed below. Those countries are: Andorra, Puerto Rico and Somalia.
No information could be obtained for Palestinian territories either.

AFRICA, SOUTH OF SAHARA

WEST AFRICA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Benin	P	P			X		X		P		P	X
Burkina Faso	P	P			X	P	X		P	X	P	X
Cape Verde	S	P				P	X		P		P	O
Chad	P	P				P	X		P		P	O
Côte d'Ivoire	P	P			X	P	X		P	X		O
Gambia		P	X				X		P		P	O
Ghana	P	P		O	X		X		P	O	P	O
Guinea-Bissau	P	P			X	P	X		P			O
Guinea	P	P				P	X		P		P	O
Liberia	P	P				P	X				P	O
Mali	P	P			X	P	X		P		P	O
Mauritania	P	P			X	P	X		P		P	
Niger	P	P			X	P	X		P		P	O
Nigeria	S	P	X		X	P	X		P		P	O
Senegal	P	P			X	P	X		P		P	O
Sierra Leone	P	P				P	X		P			O
Togo	P	P				P	X		P		P	O

CENTRAL AFRICA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Cameroon	P	P			X	P	X		P	X	P	X
Central African Republic	P	P				P	X		P		P	O
Rep. of Congo	P	P				P	X		P		P	O
Dem. Rep. of Congo	P	P					X		P		P	O
Equatorial Guinea		P				P						
Gabon	P	P				P	X		P		P	O
Sao Tome and Principe	P	P				P	X					O

SOUTHERN AFRICA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Angola	P	P	X		X				P			
Botswana		P			X		X		P		P	O
Lesotho	P	P	X						P		P	O
Malawi	P	P	X	O	X	P	X		P	O	P	X
Mozambique		P			X	P	X		P		P	O
Namibia	P	P	O	O	O	P	O		P	O	P	X
South Africa		P	X		X	P	X	1978 Act	P	X	P	X
Swaziland	S	X			X	P	X		P	X	X	O
United Rep. of Tanzania	P	P	O		X	P	X		P	X	P	X
Zambia	P	P	O		X	P	X		P	X	P	X
Zimbabwe	P	P	X		X		X		P	X	P	X

EAST AFRICA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Burundi	P	P			X	P	X		P		P	O
Djibouti	P	P				P			P		P	O
Eritrea	P	P			X	P	X					O
Ethiopia	P	P	X	X	X	P	X			O	P	O
Kenya	P	P	X		X	P	X	1978 Act	P	X	P	O
Rwanda		P			X	P	X		P		P	O
Sudan	P	P			X	P	X				P	O
Uganda	P	P	X		X	P	X		P	O	P	X

INDIAN OCEAN ISLANDS

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Comoros		P				P	O				P	O
Madagascar	P	P	O		X	P	X		P		P	O
Mauritius	P	P				P	X		P	O	P	X
Seychelles	P	P	O			P	X				P	O

AMERICAS

SOUTH AMERICA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Argentina	S	P	O		X	P	X	1978 Act	P	X	S	X
Bolivia		P	X		X	P	X	1978 Act	P	X	P	X
Brazil	P	P	X		X	P	X	1978 Act	P	X	P	X
Chile	S	P	O		X	P	X	1978 Act	P	X	S	X
Colombia	S	P	X		X	P	X	1978 Act	P	X	P	X
Ecuador	P	P	O		X	P	X	1978 Act	P	X	P	O
Paraguay	P	P			X	P	X	1978 Act	P	X	P	X
Peru	P	P	X		X	P	X		P	X	P	X
Uruguay	P	P	O		X	P	X	1978 Act	P	X	S	X
Venezuela	P	P	X		X	P	X		P	X	P	X

CENTRAL AMERICA AND MEXICO

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Costa Rica	P	P	X	X	X	P	X	1991 Act	P	X	P	X
El Salvador	P	P			X	P	X		P	X	P	X
Guatemala	P	P	X		X	P	X		P	O	P	X
Honduras	P	P			X	P	X		P		P	X
Mexico		P	X		X	P	X	1978 Act	P	X	P	X
Nicaragua	P	P	X		X	P	X	1978 Act	P	X	P	O
Panama	P	P	X		X	P	X	1978 Act	P	X	P	X

CARIBBEAN

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Antigua and Barbuda		P				P	X		P		P	O
Bahamas		P				P	X				P	O
Barbados		P				P	X		P	X	P	O

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Belize		P				P	X		P	X	P	X
Cuba	P	P	X		X	P	X		P	X	P	X
Dominica		P				P	X		P	X	P	O
Dominican Republic	P	P	O		X	P	X	1991 Act	P	X	P	O
Grenada		P				P	X		P		P	O
Guyana		P	O		O	P	X		P		P	O
Haiti	S	P				P	X		P		S	
Jamaica	P	P				P	X		P		S	O
Saint Kitts and Nevis		P				P	X		P		P	O
Saint Lucia	P	P				P	X		P		P	O
Saint Vincent and the Grenadines		P				P	X		{	O	P	O
Suriname		P				P	X		P		X	O
Trinidad and Tobago	P	P				P	X	1978 Act	P	X	P	

NORTH AMERICA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Canada	P	P			X	P	X	1978 Act	P	X	S	
United States	S	P			X	P	X	1991 Act	P	X		

ASIA AND THE PACIFIC

SOUTH ASIA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Bangladesh	P	P	X	X	X	P	X		P	X	P	O
Bhutan	P	P	X		X	P	X				P	O
India	P	P	X	X	X	P	X		P	X	P	X
Maldives	P	P				P			P		P	
Nepal		P	O	O	X	P	X		P	O	S	X
Sri Lanka		P	O		X	P	X		P	X	P	O

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Brunei		P					X		P		P	
Cambodia	P	P				P	X		P			O
Indonesia	P	P	X		X	P	X		P	X	P	X
Laos	P	P			X	P	X				P	
Malaysia	P	P	O	X	X	P	X		P	X	P	X
Myanmar	P	P			O	P	X		P		P	O
Philippines	P	P	X	O	X	P	X		P	X	P	X
Singapore		P					X	1991 Act	P	X		
Thailand	S	P	X	X	X	P	X		P	X	P	O
Viet Nam		P			X	P	X	1991 Act	P	X	P	X

EAST ASIA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
China		P	X		X		X	1978 Act	P	X	P	X
Japan		P			X	P	X	1991 Act	P	X	P	X
Korea, Dem. People's Republic of	P	P				P	X				P	O
Korea, Republic of	P	P	X		X	P	X	1991 Act	P	X	P	X
Mongolia		P				P			P		P	O

PACIFIC REGION

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Australia	P	P			X	P	X	1991 Act	P	X		X
Cook Islands	P	P				P	X				S	O
Fiji	P	P				P	X		P		P	
Kiribati	P	P					X				P	
Marshall Islands	S	P					X				P	
Micronesia		P				P	X					
Nauru		P									P	
New Zealand		P	O			P	X	1978 Act	P	X	P	X
Niue		P				P	X				P	O
Palau	P	P				P	X				P	O
Papua New Guinea		P				P	X		P		P	O
Samoa	P	P				P	X				P	O
Solomon Islands		P				P	X		P		P	
Tonga		P				P	X		P		P	O
Tuvalu		P				P	X					
Vanuatu		P	X			P	X					O

EUROPE

WESTERN EUROPE

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary regulations	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Austria	P	P			X	P	X	1991 Act	P	X	P	X
Belgium	P	P			X	P	X	1972 Act	P	X	P	X
Denmark	P	P			X	P	X	1991 Act	P	X	P	X
Finland	P	P			X	P	X	1991 Act	P	X	P	X
France	P	P			X	P	X	1978 Act	P	X	P	X
Germany	P	P			X	P	X	1991 Act	P	X	P	X
Greece	P	P	X		X	P	X		P	X	P	
Iceland	P	P				P	X	1991 Act	P		S	
Ireland	P	P			X	P	X	1978 Act	P	X	P	X
Italy	P	P	X	X	X	P	X	1978 Act	P	X	P	X
Liechtenstein		P							P			
Luxembourg	P	P			X	P	X		P	X	P	X
Monaco		P									S	
Netherlands	P	P			X	P	X	1991 Act	P	X	P	X
Norway	P	P	O		X	P	X	1978 Act	P	X	P	X

WESTERN EUROPE *(continued)*

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary regulations	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Portugal	P	P	X		X	P	X	1978 Act	P	X	P	X
San Marino		P										
Spain	P	P		X	X	P	X	1991 Act	P	X	P	X
Sweden	P	P	X		X	P	X	1991 Act	P	X	P	X
Switzerland	P	P			X	P	X	1991 Act	P	X	P	X
United Kingdom	P	P			X	P	X	1991 Act	P	X	P	X

EASTERN EUROPE

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary regulations	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Albania		P	X		X	P	X	1991 Act	P	X	P	O
Armenia	P	P			X	P	X		P	X	P	O
Belarus		P			X	P	X	1991 Act		X	P	X
Bosnia and Herzegovina		P				P						

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary regulations	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Bulgaria	P	P	X			P	X	1991 Act	P	X	P	X
Croatia	P	P			X	P	X	1991 Act	P	X	P	O
Czech Republic	P	P	X		X	P	X	1991 Act	P	X	P	X
Estonia	P	P			X	P	X	1991 Act	P	X	P	X
Georgia		P			X	P	X	1991 Act	P	X	P	O
Hungary	P	P	X		X	P	X	1991 Act	P	X	P	X
Latvia	P	P			X	P	X	1991 Act	P	X	P	X
Lithuania	P	P	O		X	P	X	1991 Act	P	X	P	X
Macedonia, Former Rep.	S	P	X		X	P	X		P	X	P	
Moldova, Rep. of		P			X	P	X	1991 Act	P	X	P	X
Montenegro	S	P									P	
Poland	P	P			X	P	X	1991 Act	P	X	P	X
Romania	P	P			X	P	X	1991 Act	P	X	P	X
Russian Federation		P			X	P	X	1991 Act		X		X
Serbia	S	P			X	P	X			X	P	X
Slovakia		P	X		X	P	X	1991 Act	P	X	P	X
Slovenia	P	P			X	P	X	1991 Act	P	X	P	X
Ukraine		P			X	P	X	1991 Act	P	X	P	

NEAR EAST

SOUTH/EAST MEDITERRANEAN

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary regulations	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Algeria	P	P			X	P	X			X	P	O
Cyprus	P	P			X	P	X		P	X	P	
Egypt	P	P	X		X	P	X		P	X	P	O
Israel		P			X	P	X	1991 Act	P	X		
Jordan	P	P	O		X	P	X	1991 Act	P	X	P	O
Lebanon	P	P	O		X	P	X					O
Libyan Arab Rep.	P	P			X	P	X				P	O
Malta	S	P	X		X	P	X		P	X	P	X
Morocco	P	P	O		X	P	X	1991 Act	P	X	S	O
Syrian Arab Republic	P	P	O		X	P	X				P	O
Tunisia	P	P			X	P	X	1991 Act	P	X	P	

WEST ASIA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary regulations	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Afghanistan	P	P	X		X	P						
Bahrain		P				P	X		P	X		
Iran, Islamic Rep.	P	P			X	P	X			X	P	O
Iraq					X	P				X		
Kuwait	P	P				P			P			
Oman	P	P				P	X		P	X	P	
Pakistan	P	P	O		X	P	X		P	X	P	X
Qatar	P	P				P	X		P		P	O
Saudi Arabia	P	P				P			P	X	P	
Turkey	P	P	X	O	X	P	X	1991 Act	P	X	P	O
United Arab Emirates	P	P			X	P	X		P			
Yemen	P	P			X	P	X			X	P	O

CENTRAL ASIA

	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights			Biosafety	
	International		National			International	National	International		National	International	National
	IT-PGRFA	CBD	Access and benefit-sharing	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)	TRIPS - WTO	Plant breeders' rights	Cartagena Protocol on Biosafety	Biosafety regulations
Azerbaijan		P			X	P	X	1991 Act		X	P	
Kazakhstan		P			X		X			X	P	X
Kyrgyz, Rep.		P			X	P	X	1991 Act	P	X	P	O
Tajikistan		P			X		X			X	P	X
Turkmenistan		P			X						P	
Uzbekistan		P			X		X	1991 Act		X		