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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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FINAL VERSION

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Editorial Note

This revised version of the *Draft Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture* (CGRFA-12/09/Inf.7 Rev.1) contains changes made in the following sections:

- Data contained in Tables 1.1, 3.1, 3.2, 3.3 and 3.4 were revised according to recent information sent to FAO by Member Countries;
- In Section 5 of the Executive Summary, a change in the number of Country Reports received for both the first *State of the World's Plant Genetic Resources for Food and Agriculture* and the *Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture* was made to be consistent with the text found in the respective chapters;
- In Section 3.4.2, changes were made in the numbers and percentages of accessions of the major and minor crops;
- In Section 3.4.2.1, the number of accessions of the total world holdings of potato accessions was changed;
- In Section 5.4.3.1 changes were made to the list of countries having adopted or drafted plant variety protection legislation to match changes made in *Appendix 1*;
- In *Annex 1*, the distribution of countries by region was revised;
- *Appendix 1* was updated based on recent information received by FAO;
- Changes were made in *Appendix 2* to the names of genus, and the percentages/ numbers of accessions;
- Previously missing *Appendixes 3* and *4* have been added; and
- Changes were made to the List of Acronyms and Abbreviations, with some acronyms deleted and others added.

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

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Foreword

Contents

List of Figures

List of Boxes

List of Tables

Acknowledgements

Preface

The first State of the World's Plant Genetic Resources for Food and Agriculture (SoW) report was presented to the Fourth International Technical Conference on Plant Genetic Resources held in Leipzig, Germany, in 1996. The Conference welcomed the report as the first comprehensive worldwide assessment of the state of plant genetic resource conservation and use. The outcome of the International Technical Conference was welcomed by the FAO Council and Conference and the Conference of the Parties to the Convention on Biological Diversity (CBD). The full version of the first SoW report was published by FAO in 1998.

The Commission on Genetic Resources for Food and Agriculture (CGRFA), at its Eighth Session, reaffirmed that FAO should periodically assess the state of the world's plant genetic resources for food and agriculture (PGRFA) to facilitate the analysis of changing needs and gaps and contribute to the adjustment of the rolling Global Plan of Action for the Conservation and Sustainable Utilization of PGRFA (GPA). It was agreed that the preparation of a second SoW report and the updating of the GPA would be considered by the CGRFA after the completion of the negotiations for the revision of the International Undertaking. The International Treaty on PGRFA (ITPGRFA) was adopted by the FAO Conference in 2001. Article 17.3 of the ITPGRFA calls upon the Contracting Parties to cooperate with the CGRFA in its periodic reassessment of the state of the world's plant genetic resources in order to facilitate the updating of the rolling GPA.

The CGRFA indicated that the second SoW report should be a high quality document, with regional and global analysis, to identify the most significant gaps and needs, in order to provide a sound basis for updating the rolling GPA. The successful updating of the GPA would contribute to the implementation of the ITPGRFA. It also indicated that the second SoW report needed to be updated with the best data and information available, including country reports, information gathering processes and thematic background studies, with the largest possible participation of countries, and should focus on changes that have occurred since 1996.

The Country Reports were the main source of information on the status and trends of plant genetic resource conservation and use at the national level. Additional sources of information were scientific literature, thematic background studies and other relevant technical publications. Throughout the preparation, FAO strived to ensure high quality of the data and that the process was country-driven, participatory, and involved relevant international organizations.

In 2004, the Guidelines for the preparation of the Country Reports were designed to serve three important interrelated functions. They are intended to:

- Assist countries to undertake a strategic assessment of their plant genetic resources for food and agriculture to provide a basis for national planning and management;
- Ensure integration of the preparation of the second SoW Report with the new approach for monitoring the implementation of the GPA;

- ➢ Provide a common framework for countries to report globally on the state of their plant genetic resources for food and agriculture and on management activities, needs and priorities.

FAO received the first Country Reports in 2006. The majority of Country Reports were received in 2008. At the time of the preparation of this document, over 106 Country Reports had been received by the Secretariat.

As approved by the CGRFA, the draft second *SoW report* comprises eight chapters. A two-step process was followed in the preparation of these chapters: a) Compilation and preparation of the draft chapters, based on Country Reports and additional information gathering; and b) organization of a technical expert meeting to ensure consistency, quality and accuracy of data.

During the preparatory process, FAO received inputs from a range of partners, including Bioversity International, the Global Crop Diversity Trust and the Secretariat of the International Treaty. Chapters of the report were also circulated to other other relevant international organizations as well as civil society and the private sector, for comments.

The second SoW report reflects the changes, gaps, needs and opportunities on PGRFA and certainly provides a solid basis for the updating of the GPA.

Executive 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 studies and published literature. It describes the most significant changes that have taken place since the first State of the World's Plant Genetic Resources for Food and Agriculture (SoW) was published and describes major continuing gaps and needs. The structure follows that of the first SoW report with an additional chapter on the contribution of PGRFA to food security and sustainable agricultural development.

1 THE STATE OF DIVERSITY

The total number of accessions conserved *ex situ* worldwide has increased by approximately 20% since 1996, reaching 7.4 million. While new collecting accounted for at least 240,000 accessions, and possibly considerably more, much of the overall increase is the result of exchange and unplanned duplication. It is estimated that less than 30% of the total number of accessions are distinct. While the number of accessions of minor crops and crop wild relatives (CWR) has increased, these categories are still generally under-represented. There is still a need for greater rationalization among collections globally.

Scientific understanding of the on farm management of genetic diversity has increased. While this approach to the conservation and use of PGRFA is becoming increasingly mainstreamed within national programmes, further efforts in this regard are needed.

With the development of new molecular techniques, the amount of 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 CWR 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, for establishing baselines and monitoring trends.

There is evidence of growing public awareness of the importance of genetic diversity, both to meet increasing demands for greater dietary diversity, as well as 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.

Awareness has increased of the importance and value of CWR and of the need to conserve them *in situ.* 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 International Union for the Conservation of Nature/Species Survival Commission. 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 CWR. 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 now being paid in several countries to increasing genetic diversity within production systems as a way to reduce risk, particularly in 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 somewhat and new legal mechanisms have been put in place in several countries to enable farmers to market genetically diverse varieties.

There is still 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, and closer collaboration and coordination are needed between the agriculture and environment sectors. Many aspects of *in situ* management still require further research and a strengthened research capacity is required in such areas as the taxonomy of CWR and the use of molecular tools for conducting inventories and surveys.

3 THE STATE OF *EX 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. Fewer countries now 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 CWR, landraces and neglected and under-utilized species is growing as land-use systems change and environmental concerns increase the likelihood of their erosion.

Many countries still lack adequate human capacity, 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. While significant advances have been made in regeneration in both national and international collections, more remains to be done. The documentation and characterization of many collections is still inadequate and where information does exist, it can often be difficult to access.

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.

The number of botanical gardens around the world now exceeds 2,500, maintaining samples of some 80,000 plant species. Many of these are CWR. Botanical gardens took the lead in developing the Global Strategy for Plant Conservation adopted by the Convention on Biological Diversity (CBD) in 2002.

The creation of the Global Crop Diversity Trust (CGDT) 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 progressed less in the case of vegetatively propagated species and species whose seeds cannot be dried and stored at low temperatures.

4 THE STATE OF USE

While assessing the overall extent and nature of PGRFA utilization remains difficult, its use as a basis for breeding improved crop varieties has changed little. There appears to have been an increase in the use of PGRFA for cultural and educational purposes.

Global plant breeding capacity has not changed significantly; a modest increase in the number of plant breeders has been reported in some countries and a decline in others. In many countries public sector plant breeding has continued to contract, with the private sector increasingly taking over. Considerably more attention and capacity building is still needed to strengthening plant breeding capacity in most developing countries.

The number of accessions characterized and evaluated has increased in all regions but not in all individual countries. More countries now use molecular markers to characterize their germplasm and undertake genetic enhancement and base broadening to introduce new traits from non-adapted populations and wild relatives.

Several important new international initiatives have been established that promote increased PGRFA use. 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 GCDT, and the new 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.

Genomics, proteomics, bioinformatics and climate change were all absent from the first SoW report but are important now, and greater prominence is also given to sustainable agriculture, biofuel crops and human health. Although progress in research and development on neglected and under-utilized species, as recommended in the first SoW report, is difficult to gauge, further efforts are needed.

There is a need in many countries for more effective strategies, policies and legislation, including seed and Intellectual Property Rights (PR) legislation, to promote a greater use of PGRFA. Good opportunities exist for strengthening cooperation among those involved in conservation and use, at all stages of the seed and food chain. Stronger links are needed, especially between plant breeders and those involved in seed systems, as well as between the public and private sectors.

5 THE STATE OF NATIONAL PROGRAMMES, TRAINING NEEDS, AND LEGISLATION

Although the first SoW report classified national programmes into three categories, it has since become clear that such a typology is too simplistic. There is huge heterogeneity among national programmes in terms of their goals, functions, organization, and structure. Of the 101 countries that contributed information for both the first and second SoW reports, 53% reported having a national programmes in 1996, whereas 71% report having some form of national programme now. In most countries national government institutions are the principal entities involved, however, the inclusion of other stakeholders, especially universities, has expanded. Many of the country reports noted that funding remains inadequate and unreliable.

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

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 (IPPC).

With respect to intellectual property rights, most developing and Eastern European countries that now provide legal protection to plant varieties, have done so in the last decade. A few others are drafting legislation.

The importance of farmers as custodians and developers of genetic diversity was recognized in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) through the provisions of Article 9 on Farmers' Rights. A few countries have now 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 August 2009, 156 countries had ratified the Cartagena Protocol on Biosafety.

6 THE STATE OF REGIONAL AND INTERNATIONAL COLLABORATION

The entry into force of the ITPGRFA in 2004 marks what is probably the most significant development since the publication of the first SoW report. The ITPGRFA is a legally binding international agreement that promotes the conservation and sustainable use of PGRFA and the fair and equitable sharing of the benefits arising out of their use, in harmony with the CBD. International collaboration is strongly promoted by the new ITPGRFA, for which FAO provides the Secretariat.

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. Good 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 a few others have become stronger. However, not all have fared well and several are largely inactive and one has ceased to function. Three new regional networks specifically addressing the issue of seed production have been established in Africa.

FAO has further strengthened its activities in PGRFA since the first SoW report, for example through establishing GIPB in 2006. The CGIAR Centres concluded agreements in 2006 with FAO, 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 Center for Biosaline Agriculture (ICBA) in 1999, the Central Asia and the Caucasus Association of Agricultural Research Institutions (CACAARI) and the Global Forum on Agricultural Research (GFAR) in 2000, the Forum for Agricultural Research in Africa (FARA) in 2002, the 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 (FONTAGRO) was set up in 1998, and in 2004 the GCDT was established as an essential element of the funding strategy of the ITPGRFA.

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. Perhaps the most far-reaching development has been the entry into force in 2004 of the ITPGRFA. The ITPGRFA established a Multilateral System of ABS that facilitates access to plant genetic resources of the most important crops for food security, on the basis of a Standard Material Transfer Agreement (SMTA). As of June 2009 there were 120 parties to the ITPGRFA. The FAO Commission on genetic resources for food and agriculture (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…'

Negotiations under the 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, the World International Property Organization (WIPO) and the World Trade Organization (WTO). There is a need for greater coordination among the different bodies involved in these discussions at the national as well as international levels.

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 have been developed in response to the CBD rather than the ITPGRFA. 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

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 - 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. PGRFA 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 the new varieties that will be needed for agriculture to adapt to the anticipated future environmental conditions. Given the time needed to breed a new crop variety, it is essential that additional plant breeding capacity be built now.

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.

In spite of the enormous contribution by PGRFA 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, to assess the impact of its use and to bring this information to the attention of policy makers and the general public so as to help generate the resources needed to strengthen programmes for its conservation and use.

CHAPTER 1

The state of diversity

1.1 INTRODUCTION

Chapter 1 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 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 summarizes what is known of changes in 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 a summary of major changes that have taken place since 1996, as well as a list of gaps and needs for the future.

Since the first SoW report was published, 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 (GM) crops has spread widely, although not without opposition. 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 crop varieties. 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. All these factors can be expected to have had an effect on the state of diversity in farmers' fields.

The development of new varieties and cropping systems adapted to the new environmental and socio-economic conditions will be crucial in order to limit yield losses in some regions and to take advantage of new opportunities in others (see section 4.9.5).[1,2,3] 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 investment in research and infrastructure (see Chapter 8).[4] Facing these challenges will require an increased use of genetic diversity, resulting on an increasing demand for novel material from the world's genebanks.

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 developed and implemented. The linkages between those primarily concerned with on farm management of PGRFA and those involved in *ex situ* conservation and use have also become stronger, 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 backlog in regeneration and overduplication continue to be areas of concern. No quantitative data were provided in the country reports on the changing status of crop wild relatives (CWR), but several countries reported on specific measures that had been undertaken to promote their conservation. Finally, there is evidence that public awareness of the importance of crop diversity, especially of formerly neglected and under-utilised species such as traditional vegetables and fruits, is growing both in developing and developed countries.

1.2.1 Changes in the 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 limited 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. The maintenance of genetic diversity within local production systems also helps to conserve local knowledge, and vice versa. With the disappearance of traditional lifestyles and languages across the globe, a large amount of knowledge about traditional crops and varieties is probably being lost, and with it much of the value of the genetic resources themselves, justifying greater attention to the on farm management of PGRFA. The concept of agrobiodiversity reserves has gained currency in this context. These are protected areas whose objective is the conservation of cultivated diversity and its associated agricultural practices and knowledge systems.

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). Having said this, it is not possible from the information provided in the country reports to make definitive statements about overall trends in on farm diversity since 1996. It seems clear that diversity on farm has decreased for some crops in some areas and countries, and the threats are certainly getting stronger; but, on the other hand, other attempts to rigorously measure changes in crop genetic diversity in the published literature have not yielded the expected evidence of erosion. This issue will be dealt in more detail in section 1.3 below.

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 section 4.6.2.

1.2.2 Changes in the status of diversity in *ex situ* collections

As reported in Chapter 3 the total number of accessions conserved *ex situ* worldwide 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 at least 240,000 accessions, and possibly considerably more (see Chapter 3). 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 16 selected 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. They are not meant to provide a comprehensive or regionally-balanced view of the global situation: they are simply the genebanks for which sufficiently high-quality data is available for both 1996 and now, allowing a reasonably estimate to be made of trends.

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 27%. However, how much of this is completely new and distinct 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 sample of 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: 60% 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 and Russian Federation). Even greater variability is to be expected across the full range of genebanks across all regions.

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 supported 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-utilised 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.

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] This may at least in part reflect a tendency for increased "repatriation" of collections. In addition, at least part of the change might reflect better management of the collections and more complete knowledge about the numbers involved. However it should also be noted that numbers of accessions 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 Cooperative 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, named AEGIS (A European Genebank Integrated System for plant genetic resources for food and agriculture). The so-called 'most appropriate accessions' are being identified among duplicate accessions, based on criteria such as genetic uniqueness, economic importance, ease of access,

TABLE 1.1
Comparison between the collections maintained by AVRDC and the CGIAR Centres in 1995 and 2008

	1995 (No.)			2008 (No.)			Change (%)		
Centre	*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**

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

TABLE 1.2

Comparison of the collections maintained by selected national genebanks in 1995 with 2008[a]

		1995 (No.)			2008 (No.)			Change (%)		
Country	**Genebank**	*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	---	---	202 581	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

TABLE 1.2 *(continued)*

Comparison of the collections maintained by selected national genebanks in 1995 with 2008[a]

		1995 (No.)			2008 (No.)			Change (%)		
Country	**Genebank**	*Genera[b]*	*Species*	*Accessions*	*Genera*	*Species*	*Accessions*	*Genera*	*Species*	*Accessions*
Russian Federation	VIR	262	1 840	328 727	256	2 025	322 238	-2	10	-2
Netherlands	CGN	30	147	17 349	36	311	24 076	20	112	39
Turkey	AARI	317	1 941	32 122	545	2 692	54 523	72	39	70
United States of America	NPGS[e]	1 582	8 474	411 246	2128	11 815	508 994	35	39	24
Average		**289**	**1 309**	**140 205**	**502**	**2 098**	**178 294**	**74**	**60**	**27**

[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; Country Reports China, 1995 and 2008; Czech Republic, WIEWS 1996 and EURISCO 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; Russian Federation, genebank manager; Netherlands, genebank manager; Turkey, 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.

conservation status and information status. The adoption of common data standards greatly facilitates the comparison of data and hence the identification of duplicates and unique accessions.[12]

1.2.3 Changes in the status of crop wild relatives

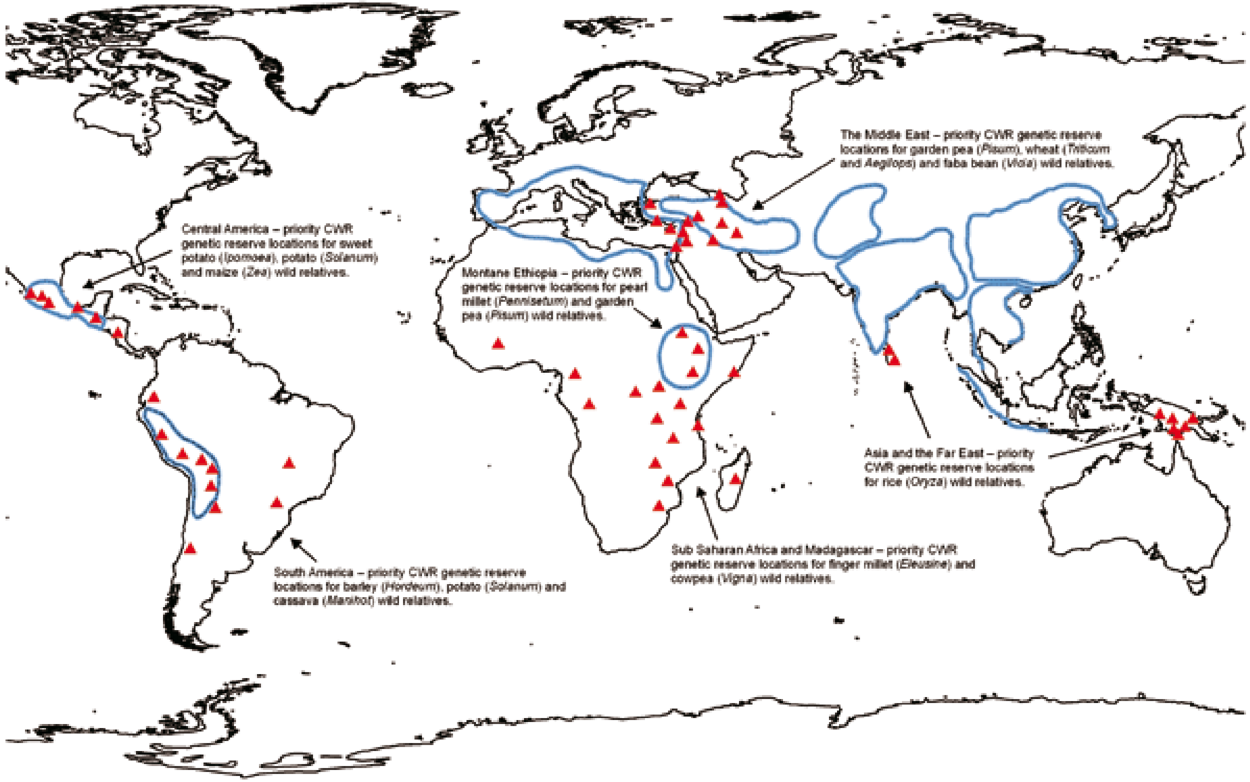
The *in situ* management of CWR is discussed in Chapter 2, and figures on the *ex situ* conservation of CWR are provided in Chapter 3. While *ex situ* conservation and on farm management methods are most appropriate for conserving domesticated crop germplasm, for CWR and species harvested from the wild, *in situ* conservation is generally the strategy of choice, backed up *ex situ*, which can greatly facilitate their use. 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 priority 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 particular genus or even species. The diversity of CWR in some existing 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 (SSA), 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 2.1). Preparatory activities, such as research and site selection, were 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) 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 and Table 2.1). 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.

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. Significant gaps exist in the taxonomic and geographic coverage of CWR in *ex situ* collections, however. A recent study by the International Center for Tropical Agriculture (CIAT) and Bioversity International has highlighted these gaps for a number of genepools.

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



Source: Maxted and Kell, 2009. 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.

Figure 1.2 summarizes the findings for the 12 crops in question.[16] It highlights areas of the world where, for these crops, CWR species are expected to exist, based on herbarium specimens, but are, however, missing from *ex situ* collections.

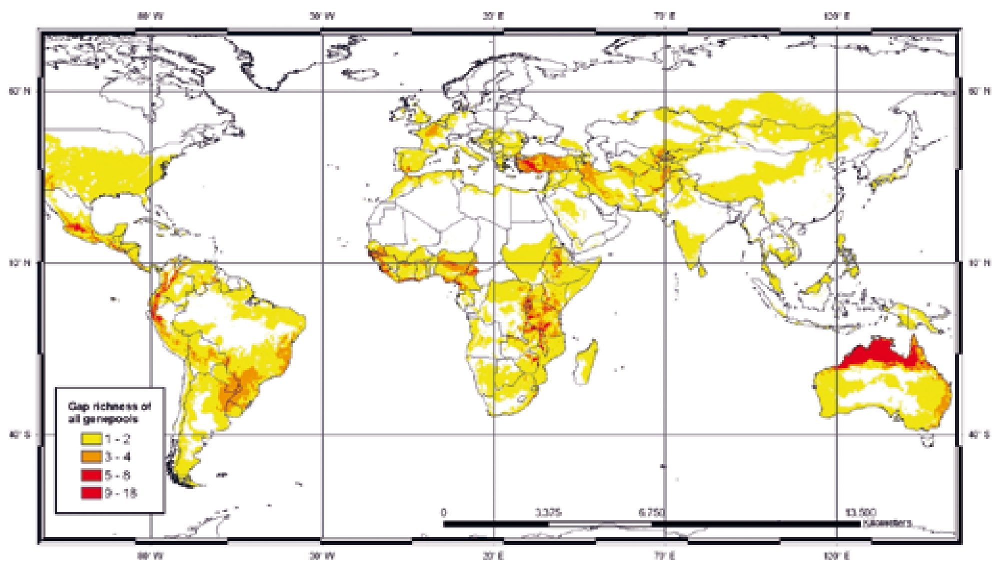
Advances in research techniques and their greater availability during the past decade have resulted in some significant new insights into the extent and distribution of genetic diversity, both in space and time, as outlined in the following sections.

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 section 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. Box 1.1 lists a few selected examples to illustrate some of the uses being made of these new techniques.

While many molecular techniques, from allele identification and marker-assisted selection to gene transformation, have been developed specifically to enhance crop

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



Source: The coloured areas are those having the greatest number of CWR, irrespective of genus. The darker the shading (orange and red) the larger the number of CWR species present.

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;[18] gaining insights into crop domestication and evolution;[19] monitoring gene flows between domesticated and wild populations;[20] and increasing the efficiency and effectiveness of genebank operations[21] (e.g. deciding what material to include within a collection;[22] identifying duplicates;[23] increasing the efficiency of regeneration,[24] 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 crop improvement.[25]

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

As defined in the first SoW report, genetic vulnerability is the "condition that results when a widely planted crop is uniformly susceptible to a pest, pathogen or environmental hazard as a result of its genetic constitution, thereby creating a potential for widespread crop losses". Genetic erosion, on the other hand, was defined as "the loss of individual genes, and the loss of particular combinations of genes (i.e. of gene complexes) such as those maintained in locally adapted landraces. The term 'genetic erosion' is sometimes used in a narrow sense, i.e. the loss of genes or alleles, as well as more broadly, referring to the loss of varieties". 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.[26] These definitions take into account both sides of the diversity coin, that is richness and evenness, the first relating to the total number of alleles present and the second to the relative frequency of different alleles. 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 60 report that genetic vulnerability is significant 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 was concern that the current agricultural system is dominated by monocultures, in particular of yam and commercial crops. China reported cases in which rice and maize varieties have become more uniform and thus more genetically vulnerable. Ecuador reports that endemic plants are particularly vulnerable due to their restricted distribution. In the Galapagos Islands, at least 144 species of native vascular plants are considered rare; 69 of these are endemic to the Archipelago, including 38 species which are restricted to a single island. In Lebanon the decrease in the national production of almonds has been attributed to the genetic vulnerability of the few varieties grown. The largest global example of the impact of genetic vulnerability that has occurred since the first SoW report was published is the outbreak and continued spread of the Ug99 race of stem rust, to which the large majority of existing wheat varieties is susceptible. On the other hand, some countries reported on successful measures to counter genetic vulnerability. Cuba, for example, reported 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.

In the case of genetic erosion, while the country reports mention 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, inappropriate legislation and policy, and pests, diseases and weeds. From an analysis of 104 country reports it also appears that genetic erosion may be greatest in cereals, followed by vegetables, fruits and nuts, and food legumes (see Table 1.3). This may however be an artifact of the greater attention generally paid to field crops.

The following examples of genetic erosion cited in five of the country reports give a flavour of the diversity of situations and may serve to illustrate the overall situation. The list is not intended to be complete and as the information contained in the country reports was not standardized, it is not possible to make cross-country or cross-crop comparisons, or use the information as a baseline for future monitoring. 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 (*Coffea 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.[27] Yemen reports that finger millet varieties *Eleusine crocana* and *Eragrostis tef* as well as oil rape varieties *Brassica napus* and *napus*, which used to be among the important traditional crops grown in the country, are no longer grown or only grown in very specific areas whereas the cultivation of wheat, including *Triticum dicoccum*, has drastically decreased. In Albania, all primitive wheat cultivars and many maize cultivars have reportedly been lost.

Notwithstanding such reports of the loss of local varieties, landraces and CWR, the situation regarding the true extent of genetic erosion is clearly very complex. While some recent studies have confirmed that diversity in farmers' fields and in protected areas has indeed decreased, it is not possible to generalize, and in some cases there is no evidence that it has occurred at all. For example, a large on farm conservation project that studied genetic diversity in farmers' fields in nine developing countries found that, overall, crop genetic diversity continued to be maintained.[28] Other studies, however, have reported genetic shifts in farmers' varieties, for example in pearl millet in Niger[29] and sorghum in Cameroon,[30] and in studies on the adoption by farmers of improved varieties of rice in India[31] and Nepal,[32] 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

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

Crop group	Number of countries reporting genetic erosion
Cereals and grasses	30
Forestry species	7
Fruits and nuts	17
Food legumes	17
Medicinal and aromatic plants	7
Roots and tuber	10
Stimulants and spices	5
Vegetables	18
Miscellaneous others	6

on farm diversity rather than reduce it.[33] In summary, it seems that general statements purporting to quantify the overall amount of genetic erosion that has occurred over the past decade are not warranted.

As with the situation of traditional farmer varieties and CWR, studies on diversity trends within 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's (CIMMYT) spring bread wheat varieties,[34] maize and pea varieties in France,[35] fruit varieties in Yemen[36] and barley in Austria and India[37]. 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,[38] or a continuous decline such as for wheat in China,[39] oats in Canada,[40] and maize in Central Europe.[41] 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.[42] However, the context of the meta analysis needs to be carefully considered to understand whether the results might be extrapolated, in particular to developing country conditions and a wide range of different crops.

Whereas convincing evidence may be lacking for genetic erosion in farmer varieties on the one hand and released varieties on the other hand, much more consensus exists on the occurrence of genetic erosion as a result of the total shift from traditional production systems depending on farmer varieties to modern production systems depending on released varieties.

1.3.2 Indicators of genetic erosion and vulnerability

Over the last decade, interest in direct and indirect indicators of genetic vulnerability and erosion has increased, at least in part due to the paucity of direct evidence for either process. 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 and give these more weight than less 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 extent 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;
- 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.

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 geography 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 the borders of the country where they happen to be working. 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. This can be seen as either a potential threat to national sovereignty or as an opportunity for constructive collaboration[43] (see Figure 1.3 and Table 1.4).

The concept of interdependence applies not only at the international level, but also in the respective roles of farmers, breeders and genetic resource managers. Farmers are the managers of the 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 raw materials they need to produce new varieties for farmers' use. All are interdependent.

Considerable interdependence also occurs at the local level among 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[44] since their high level of interdependence contributes to their resilience.

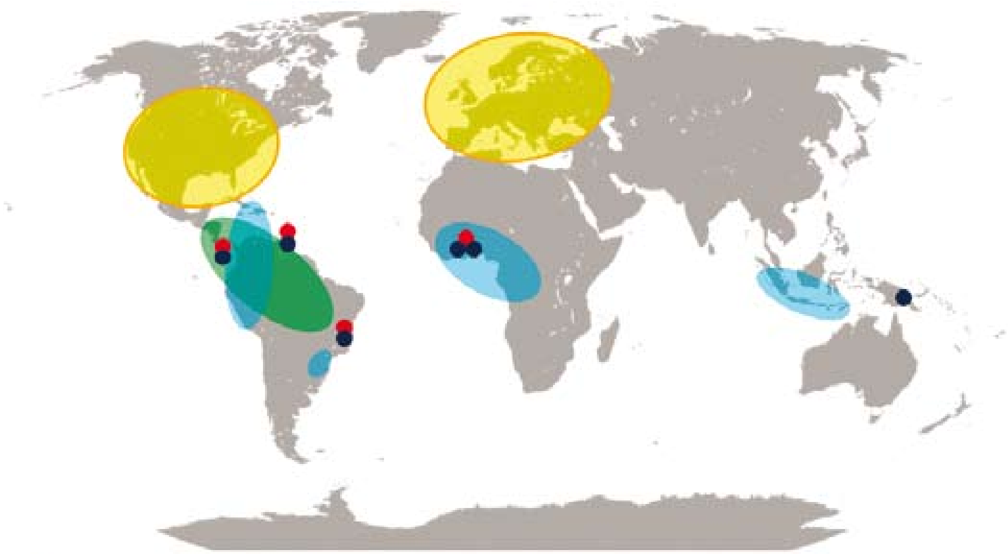
At the regional and global levels, a major consequence of interdependence among nations is the need for international exchange of germplasm. Studies have suggested that in many cases such exchange has become more complex and difficult over recent years. There is a danger that reduced international flows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

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 the 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 join the ITPGRFA and it is important, for ensuring the facilitated flow of PGRFA to all who need to access it, that as many countries as possible ratify the ITPGRFA and put in place the necessary procedures to ensure its effective implementation.

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

FIGURE 1.3
Global interdependence illustrated by the example of cacao



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)[45] and the development of regional centres of excellence for biotechnology, such as Biosciences Eastern and Central Africa (BECA).[46] 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 unplanned 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-utilised species 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. The picture that is emerging is complex and it is not possible to draw clear conclusions 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 access.

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 better characterization, evaluation and documentation of the collections;
- A better understanding of, and support for, farmers' management of diversity is still needed, in spite of significant advances in this area. Opportunities exist for improving the livelihoods of rural communities an essential element of such efforts;

TABLE 1.4
Indicators of global interdependency of selected crops

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	United States of America, France, Germany, Russian Federation, Japan	Cocoa beans Netherlands, United States of America, Malaysia, Germany, Belgium
Quinoa (*Chenopodium quinoa*)	Andean Cordillera	United States of America, CGIAR	Peru, Bolivia, Ecuador	Peru, Bolivia	Bolivia, Peru, United States of America, Europe, Canada	N/A
Soybean (*Glycine max*)	East Asia	China, AVRDC (Regional), United States of America, Ukraine, Russian Federation	United States of America, Brazil, Argentina, China, India		Seed China, Indonesia, Japan, Brazil, Rep. of Korea Oil China, United States of America, Brazil, India, Japan	China, Netherlands, Japan, Mexico, Germany
Safflower (*Carthamus tinctorius*)	Far East, India, Pakistan, the Middle East, Egypt, Sudan, Ethiopia, Southern Europe	Mexico, India, China, Ethiopia, United States of America	India, United States of America, Kazakhstan, Australia, China	Australia, Canada, China, India, Mexico, Spain, United States of America	Seed Belgium, Netherlands, China, United Kingdom, Philippines Oil United States of America, Netherlands, Japan, Germany, Yemen	Safflower seed Belgium, Netherlands, China, United Kingdom, Philippines
Noug (*Guizotia abyssinica*)	Horn of Africa	Ethiopia, India	Ethiopia, India, Nepal	Ethiopia, India	Ethiopia, India, United States of America, United Kingdom, Nepal	United States of America, 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, United States of America	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	Iraq, United States of America, France, Germany, United Kingdom
Sunflower (*Helianthus annuus*)	North America	Romania, Serbia, United States of America, Russian Federation, France	Russian Federation, Ukraine, Argentina, China, India, France, United States of America, Hungary, Turkey	United States of America, Russian Federation	Seed United States of America, Spain, Myanmar, Bulgaria, Brazil Oil Russian Federation, China, Ukraine, India, Spain	Sunflower seed Spain, Netherlands, Turkey, Italy, France

TABLE 1.4 *(continued)*
Indicators of global interdependency of selected crops

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]
Groundnut (*Arachis hypogea*)	South America	ICRISAT, USDA, India, China, Senegal,Brazil	China, India, Nigeria, United States of America, Indonesia	India, China, United States of America, Australia, Brazil	<u>Confectionary</u> China, United States of America, Indonesia, India Nigeria; <u>Oil</u> China, India, Nigeria, Sudan, Myanmar	<u>Groundnut shelled</u> Netherlands, Russian Federation, Mexico, Canada, United Kingdom
Rice (*Oryza* spp.)	South, East, and South-East Asia, Africa	Philippines (CGIAR), China, India, United States of America, Benin (CGIAR), Thailand	China, India, Indonesia, Bangladesh, Viet Nam	Philippines (CGIAR), United States of America, China, India	China, India, Indonesia, Bangladesh, Viet Nam	<u>Rice, milled</u> 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	China, India, Netherlands, Pakistan, Germany
Wheat (*Triticum aestivum*)	Central Asia, East Asia, South Asia, West Asia, East Africa, Europe, South and East Mediterranean	CGIAR, United States of America, Russian Federation, Italy, Australia	China, India, United States of America, Russian Federation, France	United States of America, Australia, Brazil, France, China, India, CGIAR, Canada, United Kingdom	China, India, United States of America, Russian Federation, Pakistan	Italy, Brazil, India, Egypt, Japan
Maize (*Zea mays*)	Central America and Mexico, North America, South America, Asia	India, Russian Federation, United States of America, CGIAR, Mexico	United States of America, China, Brazil, Mexico, Argentina	United States of America, CGIAR, Europe, Brazil, China, India, Africa	China, Mexico, Indonesia, India, South Africa	Japan, Republic of Korea, Mexico, China, Spain
Potato (**Solanum tuberosum**)	South America	CGIAR, Colombia, Japan, Netherlands, Czech. Rep.	China, Russian Federation, India, United States, Ukraine	CGIAR, USA, China, India, Canada, Holland, Poland, United Kingdom, France, Germany, Chile, Argentina, Colombia, Ecuador, South Africa, Republic of Korea, Australia	China, USA, India, Russian Federation, United Kingdom	Netherlands, Belgium, Spain, Germany, Italy

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

- There is still a need for greater rationalization of the global system of *ex situ* collections, as called for in the GPA and the ITPGRFA, and as reflected in initiatives such as those of the GCDT and AEGIS;
- Greater attention is needed regarding the conservation and use of PGRFA of neglected and under-utilised crops and non-food crops. Many such species can make a valuable contribution to improving diets and incomes;
- There is a need to promote standard definitions and means of assessing genetic vulnerability and genetic erosion, as well as to agree on more and better indicators, in order to be able to 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 for the management of diversity - or if they have them, they do not fully implement them. Areas that require particular attention include setting priorities, enhancing national and international cooperation, the further development of information systems 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

Examples of the use of molecular tools in the conservation and characterization, as reported in selected country reports

Africa

- *Benin:* Molecular characterization of yam germplasm has been initiated.
- *Burkina Faso*: Molecular characterization of millet, sorghum, taro, bean, *Abelmoschus esculentus, Macrotyloma geocarpum, Pennisetum glaucum, Solenostemon rotundifolius, Sorghum bicolour, Colocasia esculenta, Vigna unguiculata, Ximenia americana.*
- *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.
- *Namibia*: Genetic diversity studies in sorghum and *Citrullus*.
- *Niger*: Molecular characterization of millet has been initiated.
- *United Republic of Tanzania*: Molecular markers have been used for 50 percent of coconut collection, 46 percent of cotton *Gossypium* spp. collection and 30 percent of cashew nut *Anacardium occidentale* collection.
- *Zimbabwe*: Molecular characterization has been done on landraces collected in the Nyanga and Tsholotsho areas and for accessions held in the Genetic Resources and Biotechnology Institute.

Americas

- *Bolivia*: Molecular characterization has been applied to a limited number of collections, primarily Andean root and tuber crops.
- *Brazil*: GIS studies on the distribution of wild relatives of groundnut.
- *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.
- *Ecuador*: Molecular characterization and evaluation has been completed for several crop species.
- *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*: Molecular characterization of sugar cane, cacao, potato, and cotton genebank accessions, among other taxa, has been carried out.

BOX 1.1 *(continued)*

Examples of the use of molecular tools in the conservation and characterization, as reported in selected country reports

Asia and the Pacific

- *Bangladesh:* Molecular characterization of lentil and barley has been carried out through collaboration between the Bangladesh Agricultural Research Institute and the International Centre for Agricultural Research in Dry Areas (ICARDA).
- *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.
- *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.* The country 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.
- *Estonia*: Molecular markers were used to map some wheat accessions.
- *Finland*: Molecular marker analysis has been used in estimations of genetic diversity in CWR.
- *Greece*: Molecular characterization and evaluation of cereal and vegetable crops have 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*) was carried out.

BOX 1.1 *(continued)*

Examples of the use of molecular tools in the conservation and characterization, as reported in selected country reports

- *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 has been partially carried out.
- *Netherlands*: The Centre of Genetic Resources's collections of lettuce (2,700 acc), and (partly) Brassica (300 acc.) and potato (300 ac.) and a selection of 8 Dutch apple collections (800 acc.) have been screened in order to improve insight into the collection structure, whereas part of the potato collection (800 acc.) has been analysed by molecular means for the presence of certain potential resistance genes.

Near East

- *Cyprus*: Molecular tools for the assessment of genetic material have been introduced and molecular assessment for tomato accessions is in process.
- *Egypt:* Molecular genetic data employed in PGR evaluation of accessions in national genebank.
- *Islamic Republic of Iran*: Molecular markers have been integrated into characterization programs of national plant genebank, and marker assisted selection and genetic transformation technologies are being used for breeding new cultivars.
- *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.
- *Kazakhstan:* The assessment of genetic diversity and study of pedigree using molecular markers was made for wheat and barley.
- *Lebanon:* Molecular genetic characterization has been conducted for olive and almond varieties.
- *Morocco*: Molecular markers and GIS have been used in evaluation of germplasm of cereals to target regions for collection.
- *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, D.L., Burke, M.B., Tebaldi, C., Mastrandea, M.D., Falcon, W.P. and Naylor, R.L.** 2008. Prioritizing Climate Change Adaptation Needs for Food Security in 2030. *Science*, 319: 607-610.

3 **Jarvis, D.I., Brown, A.H.D., Sadiki, S., Ouedraogo, J., Zangre, R., Rhrib, K., Chavez, J.L., Schoen, D.I., Sthapit, B,R., De Santis, P., Fadda, C., and Hodgkin, T.** 2007. A global perspective of the richness and evenness of traditional crop-variety diversity maintained by farming communities. *Proceedings of the National Academy of Science*, USA, 105: 5326-5331.

4 **Rosegrant, M.W. and Cline, S.A.** 2003. Global food security: challenges and policies. *Science*, 302: 1917-1919.

5 **Lang, T.** 2003. Food industrialisation and food power: Implications for food governance. *Development Policy Rev*. 21: 555–568.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 United States of America has doubled since 1967 and the share held by the top three grocery retailers in EU countries varies from 40 percent (Germany, UK) to over 80 percent (Finland, Ireland).

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

7 In the context of this chapter staple crops include the large cereals (wheat, maize, rice, sorghum and barley), and beans, cowpeas, groundnuts, potatoes, bananas and cassava.

8 Section 3.3.4 in the first SoW report, Coverage of collections and reaming gaps.

9 **Hammer, K**. 2003. A paradigm shift in the discipline of plant genetic resources. *Genetic Resources and Crop Evolution*, 50: 3–10.

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15 **Jarvis, A., Lane, A. and Hijmans, R.J.** 2008. The effect of climate change on crop wild relatives. *Agriculture, Ecosystems and Environment*, 126(1): 13-23.

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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 taking place in protected areas or habitats (as opposed to *ex situ* conservation) and 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 CWR.

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 conservation and management of PGRFA in wild ecosystems, agricultural production systems and the interface between the two. It reviews new knowledge regarding the amount and distribution of diversity of landraces, CWR and other useful plants, and assesses current capacity for conserving and managing diversity *in situ*. The chapter describes a few major global challenges, summarizes the main changes that have occurred since the first SoW report was published and concludes by identifying 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 may 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] However, natural grasslands are becoming 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. In many cases the conservation and use of natural grasslands is important in strategies to conserve and use animal genetic resources.

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. Switzerland, for example, completed an inventory of its CWR in 2009 in which 142 species were identified as being of priority for conservation and use.[5] Most surveys, however, have been limited to single crops, small groups of species or to limited areas within the national territory.[6] 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.[7] 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,[8] 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 ecosystems and the latter mainly on the *ex situ* conservation of domesticated crops. As a result, the conservation of CWR has been relatively neglected.[9] Efforts to redress this situation have included a global project led by Bioversity International, to promote 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[10] 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.[11] In Venezuela, between 1997 and 2007, 32 inventories and surveys have been carried out prioritizing areas of the country where PGRFA were at risk. Jordan, Lebanon, the Palestinian Authority and the Syrian Arab Republic 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.

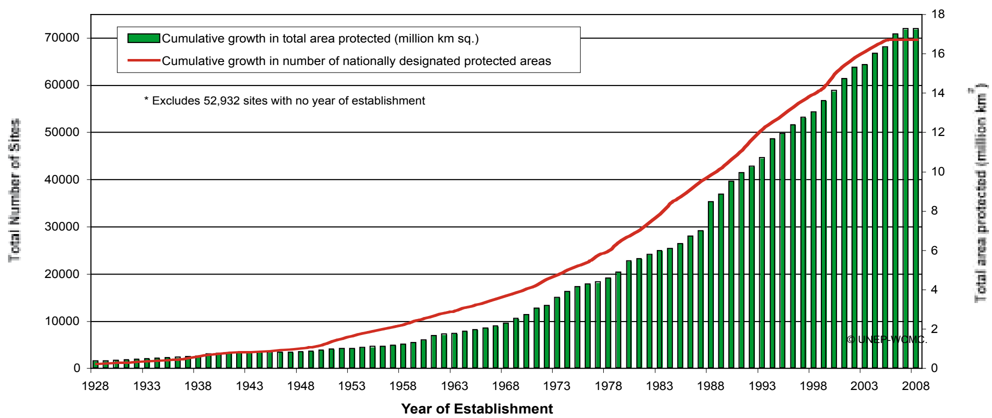
At the regional and global level, efforts have been made by several international organizations to carry out inventories and to determine the conservation status of wild plants. An analysis of the International Union for the Conservation of Nature's (IUCN) Red List of Threatened Species[12] shows that of the14 important crops for food security, 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 assessed globally, the majority of which are relatives of the potato.[13] The IUCN Species Survival Commission (SSC) has established a new CWR 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.[14] The most comprehensive inventory of CWR is the catalogue for Europe and the Mediterranean,[15] 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.[16]

Many of the country reports listed major obstacles to systematic national inventorying and surveying of PGRFA. These include: lack of funding, lack of human resources, skills and knowledge,[17] lack of coordination and unclear responsibilities,[18] low national priority,[19] inaccessibility of *in situ* areas,[20] 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 2.1).[21] This expansion is reflected at the national level

FIGURE 2.1
Growth in nationally designated protected areas (1928-2008)*



Source: World Database on Protected Areas (WDPA).[23]

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 pledged that one third of its territory would be protected by 2008.[22]

Figure 2.1 shows the cumulative growth in nationally designated protected areas (marine and terrestrial) in both total number of sites and total area protected (km^2) from 1928 to 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[24] it was observed that, in general, areas with the greatest diversity (e.g. within 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[25] and drawing attention to specific action needed.[26] 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[27] has shown that conservation activities can take many forms including field or database inventories and mapping;[28] ecogeographic surveys;[29] investigation of policy structures and decision-making;[30] studies of traditional and indigenous ethnobiology;[31] and monitoring of CWR once management plans have been adopted.[32]

While a global survey of *in situ* conservation of wild PGRFA,[33] 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 (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;[34]
- Mali reported that wild fruit trees important for food security are managed in protected forests, and in southern United Republic of 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*;[35]
- The Sierra de Manantlán Reserve in Southwest Mexico has been established specifically for the conservation of the endemic perennial wild relative of maize, *Zea mays*;
- 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.[36] 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 Viet Nam, *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;[37]

- In Europe, surveys have been carried out on wild *Prunus* species[38] and wild apples and pears.[39] The European Crop Wild Relative Diversity Assessment and Conservation Forum[40] has established *in situ* conservation methodologies for CWR[41] 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 (for example *Triticum araraticum, T. boeoticum, T. urartu, Secale vavilovii S. montanum, Hordeum spontaneum, H. bulbosum* and *H. glaucum*)[42] 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 the Near East, in addition to the protected area established in Turkey for conserving wild relatives of cereals and legumes, in 2007 the Syrian Arab Republic 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.[43]

2.2.3 *In situ* conservation of PGRFA outside protected areas

A World Bank study[44] 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 important PGRFA species, including CWR and useful plants collected from the wild, occur outside conventional protected areas and consequently do not receive any form of legal protection.[45] Cultivated fields, field margins, grasslands, orchards, recreation areas 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.[46]

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 conservation agencies and those who own or have rights over prospective sites. Such agreements are becoming more common, especially in North America and Europe. Micro-reserves, for example, have been established in the Valencia region of Spain.[47] 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 and other useful 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, especially in developed countries[48] 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.[49] Several countries in West Africa, for example, 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, few details have been provided. In Viet Nam, a research project on the *in situ* conservation of landraces and CWR outside 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'[50] project focuses on the conservation of wild plant species (including CWR) outside of protected areas through establishing a nationwide conservation 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.[51] It has also been reported that in Jabal Sweida in the Syrian Arab Republic, rare wheat, barley, lentil, pea and faba bean CWR are common in modern apple orchards.[52]

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[54] 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.).

TABLE 2.1
Summary of 14 priority CWR species as reported by Maxted and Kell, 2009

Crop	High priority CWRs	Centers of diversity	Likely occurrence inside protected area	Known occurrence inside protected area	Known occurrence outside protected area	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

TABLE 2.1 *(continued)*
Summary of 14 priority CWR species as reported by Maxted and Kell, 2009

Crop	High priority CWRs	Centers of diversity	Likely occurrence inside protected area	Known occurrence inside protected area	Known occurrence outside protected area	Countries in which suggested priority site/ areas should be located	Suggested sites are specific protected areas or in their vicinity? (Y/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, Syrian Arab Republic, Turkey, Yemen	N
Potato *(Solanum tuberosum)*	110 species with 5 or fewer observation records[53]	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, Islamic Republic of Iran, Iraq, Lebanon, Turkey	N (except one)

TABLE 2.1 *(continued)*
Summary of 14 priority CWR species as reported by Maxted and Kell, 2009

Crop	High priority CWRs	Centers of diversity	Likely occurrence inside protected area	Known occurrence inside protected area	Known occurrence outside protected area	Countries in which suggested priority site/ areas should be located	Suggested sites are specific protected areas or in their vicinity? (Y/N)
Faba bean *(Vicia faba)*	*V. eristalioides*	Mediterranean		x			Y
	V. faba subsp. *paucijuga* *V. galilaea* *V. hyaeniscyamus* *V. kalakhensis*				x	Syrian Arab Republic, Turkey	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 CGRFA. Rome, Italy. 266 pp.

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*), faba bean (*Vicia* spp.), chickpea (*Cicer* spp.), alfalfa (*Medicago* spp.), clover (*Trifolium* spp.) and wild relatives of fruit trees, particularly, Pistachio (*Pistacia* spp.) and stone fruits (*Prounus* 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[55] 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 publication of the first SoW report. 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 a clearer understanding of the factors that influence it.[56] New tools have been developed that enable this diversity, and the processes by which it is maintained, to be more accurately assessed and understood[57] 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 to the country reports, published scientific literature since the first SoW report contains a considerable amount 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.[58] In a study in Nepal and Viet Nam of whether traditional rice varieties are grown by many households or only a few, and over large or small areas,[59] 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.[60]

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, and 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 Viet Nam 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.[61]

A recent review[62] revealed that traditional 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 indicated that 'informal' seed systems remain a key element in the maintenance of crop diversity on farm (see section 4.8) and can account for up to 90% of seed movement.[63] 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.[64]

Access to seeds of traditional varieties of field crops 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 EU directive 2008/62/EC provides for a certain flexibility in the registration and marketing of traditional, locally adapted but threatened agricultural landraces and varieties; so-called 'conservation varieties'. For more information on seed legislation and its impacts see section 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 can result 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.[65]

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[66] and can be important sources of seeds for local farmers.

A sharp decrease in the number of farmers growing a particular variety, and a switch to a single, or restricted number of new varieties, can create a genetic bottleneck and may result in the loss of genetic diversity. This can occur, for example, 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[67] and it continues to be important today.[68] 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.[69] At the same time, many wild relatives and crop cultivars avoid losing their identities even when they grow in close proximity, often using reproductive mechanisms such as pollen competition. This can happen for example when a wild relative is surrounded by cultivated fields, as in the teosinte-maize relationship in Mexico,[70] and in the opposite case when wild relatives surround crop fields, such as pearl millet in the Sahel.[71]

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 in the Syrian Arab Republic, natural gene flows between cultivated and wild *Triticum* species were confirmed using morphological and molecular techniques.[72]

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 greater 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.[73] Age, gender, ethnic group and wealth status all have a bearing on who maintains diversity, what diversity is maintained and where (see Chapter 8). 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 United Republic of Tanzania, for example, all describe efforts to document and protect indigenous knowledge, while many others state the need to do so or for appropriate policies to this end.

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 Viet Nam 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.[74]

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.

2.3.4.1 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 made to characterize traditional and local varieties over the past decade, and the Czech Republic reported that state financial support is available for the evaluation of neglected crops.

2.3.4.2 Improving local materials through breeding and seed processing

Improvement of local materials can be achieved through plant breeding and/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.[75]

2.3.4.3 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.[76] Albania, Azerbaijan, Jordan, Malaysia, Namibia, Nepal, Pakistan, Portugal, Philippines and Thailand, for example, 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.[77] 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.

2.3.4.4 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.[78] Ethiopia, Cuba, Nepal, Peru and Viet Nam all report that 'diversity fairs' allow their farmers to see the extent of diversity available in a region and to exchange materials. In Azerbaijan, for example, action was taken by the government to improve farmer's PGRFA knowledge. These have proven to be a popular and successful way of strengthening local knowledge and seed supply systems.[79] 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.

2.3.4.5 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 to support the use of traditional varieties. In Cyprus, for example, 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)[80] 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 addition, 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 briefly below.

2.4.1 Climate change

Many country reports[81] refer to the threat of climate change to genetic resources. All the predicted scenarios of the Intergovernmental Panel on Climate Change (IPCC)[82] 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.[83] 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[84] 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[85] 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.

Ex situ conservation will become increasingly important as a safety net for conserving PGRFA that is threatened with extinction due to climate change. At the same time, the genetic diversity conserved in genebanks will become increasingly important in underpinning the efforts of plant breeders as they develop varieties adapted to the new conditions. Likewise *in situ* conservation, because of its dynamic nature, will also become more important in the future as a result of climate change. In cases where *in situ* populations of CWR and landraces are able to survive climate change, their evolution under climatic selection pressure will result in populations that may not only be important in their own right but also have the potential to contribute valuable new traits for crop genetic improvement.

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, Slovakia 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.[86] Cyprus reported that a variety of crop species are known as invasive alien species and are having negative effects to local biodiversity.

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 40 of the country reports (see Chapter 1). Ecuador reported this effect in the Sierra region. Georgia, for example, cited the fact that local varieties of apples and other fruits were being replaced by introduced modern varieties from abroad and Pakistan reported 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. Jordan reported crops such as wild almond and historical olive trees under threat due to the replacement by the new varieties.

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 studies 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 by governments as a basis for action;[87]
- 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 and coordination, nationally and internationally, 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;
- Greater measures are needed in many countries to counter the threat of alien invasive species;
- Strengthened research capacity is required in many areas, and in particular in taxonomy of CWR, and 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 better inventories and characterization data on land races, CWR and other useful wild species, including forages, in order to better target *in situ* conservation action;
  - Studies on the reproductive biology and ecological requirements of CWR and other useful wild species;
  - 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 the Syrian Arab Republic, 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 aestivum*, *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 specialized facilities known as genebanks maintained by public or private institutions either acting alone or networked with other institutions. PGRFA can be conserved 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 also 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

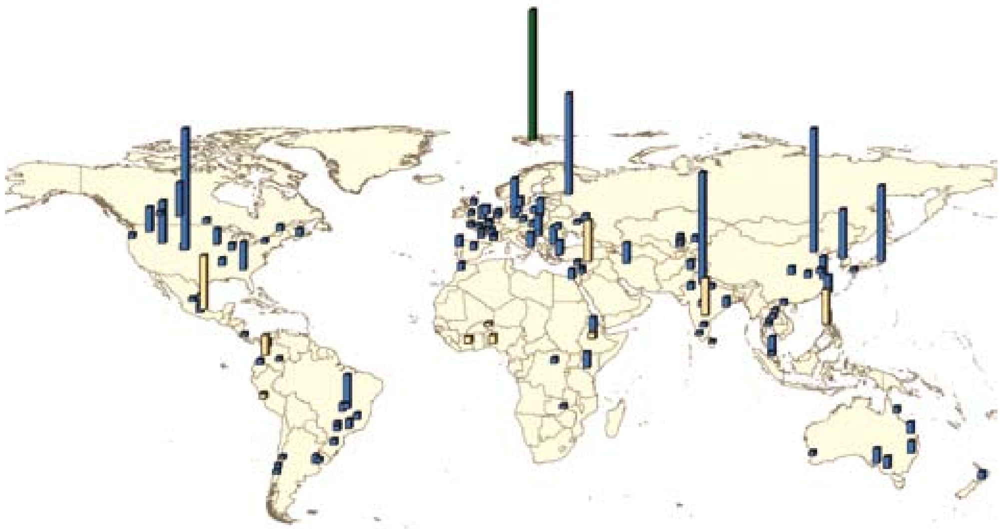
There are now more than 1,750 individual genebanks worldwide, about 130 of which hold more than 10,000 accessions each. There are also substantial *ex situ* collections in botanical gardens, of which there are over 2,500 around the world. Genebanks are located on all continents, but there are relatively 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 brought under the ITPGRFA (see Chapter 7).

Based on figures in WIEWS[1] and country reports, it is estimated that currently about 7.4 million 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.[2] Of these, about 51% is conserved in more than 800 genebanks of the Contracting Parties of the ITPGRFA and 13% is stored in the collections of the CGIAR Centres. Of the total 7.4 million accessions, national government genebanks conserve about 6.6 million, 45% of which is held in only seven countries[3] down from 12 countries in 1996. This increasing

FIGURE 3.1

Geographic distribution of genebanks with holdings of >10,000 accessions (national and regional genebanks (blue); CGIAR Centres genebanks (beige); SGSV[4] (dark green)[5]



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[6]	Sub-region	Number of accessions
Africa	East Africa	145 644
Africa	Central Africa	20 277
Africa	West Africa	109 831
Africa	Southern Africa	70 650
Africa	Indian Ocean Islands	4 604
Americas	South America	687 012
Americas	Central America and Mexico	303 021
Americas	Caribbean	33 115
Americas	North America	740 119
Asia and the Pacific	East Asia	1 039 134
Asia and the Pacific	Pacific	252 455
Asia and the Pacific	South Asia	714 562
Asia and the Pacific	Southeast Asia	290 097
Europe	Europe	1 725 777
Near East	South/East Mediterranean	141 015
Near East	Central Asia	153 849
Near East	West Asia	165 930

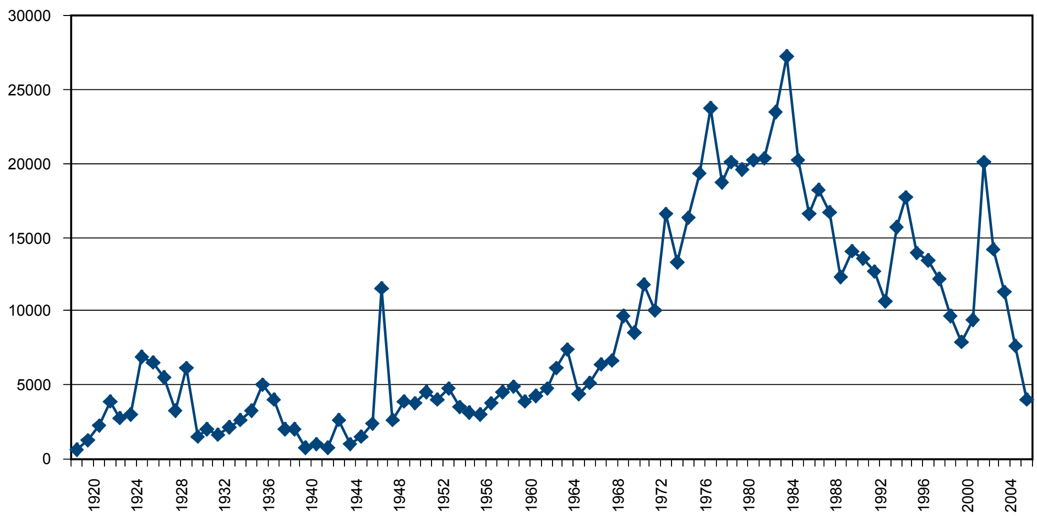
Source: WIEWS 2009 and Country Reports concentration of *ex situ* germplasm in fewer countries and research centers highlights the importance of mechanisms to ensure facilitated access, such as that of the multilateral system under the ITPGRFA.

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

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 CWR. 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.[7] 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[8], including those of the CGIAR Centres, 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.[9]

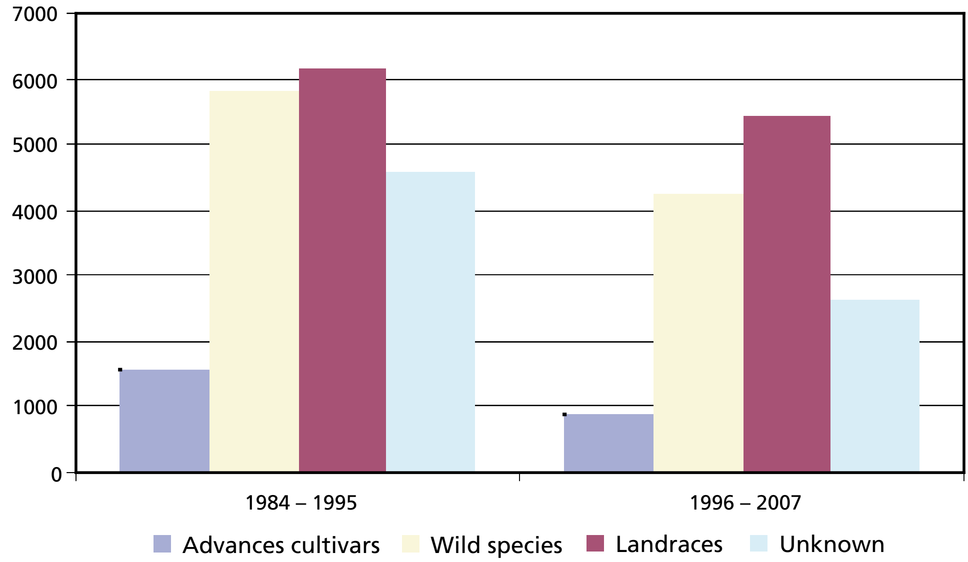
FIGURE 3.2
Number of accessions collected each year since 1920 and stored in selected genebanks, including those of the CGIAR Centres



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); KARI-NGBK (Kenya) (source: dir. info. 2008); INIAP/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 is 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, 1984-95 and 1996-2007



Source: genebanks of the NPGS of USDA (source GRIN 2008); 234 genebanks from Europe (source EURISCO 2008); 12 genebanks from SADC (source SDIS 2007); KARI-NGBK (Kenya) (source: dir. info. 2008); INIAP/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).

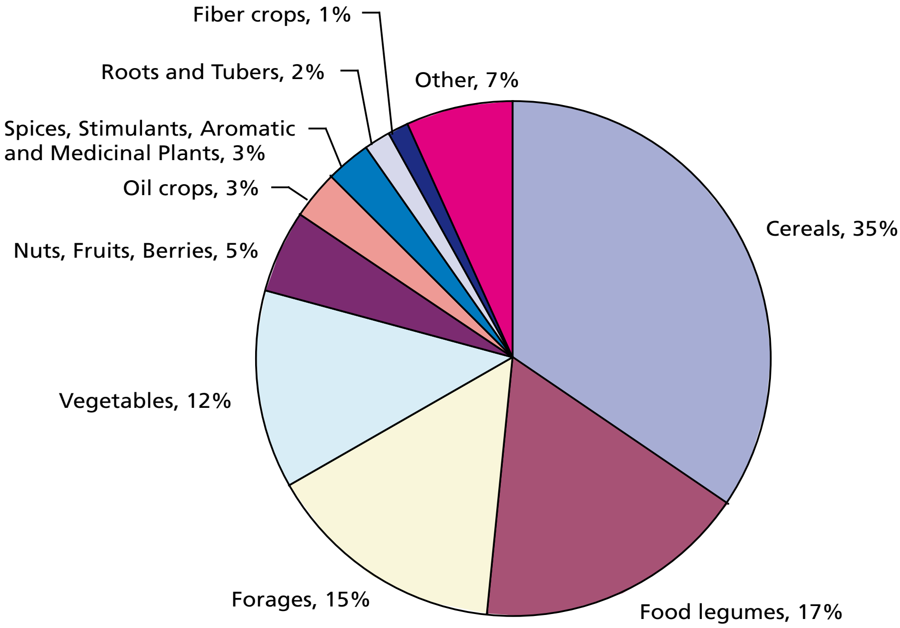
3.3.1 Situation in the regions

Most collecting missions during the last ten years have taken place in country and 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 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.[10]

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, United Republic of Tanzania, Togo and Zambia all reported the collecting of germplasm

FIGURE 3.4
Accessions collected by selected genebanks over the period 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); KARI-NGBK (Kenya) (source: dir. info. 2008); INIAP/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).

over recent years. Five missions were organized in Ghana that yielded nearly 9,000 new accessions of legumes, maize, roots and tubers, and 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 reported to have been collected in South America. In North America, the United States Department of Agriculture (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* (2,795), *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 Saint 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. 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, Cook Islands, Fiji, Palau, Papua New Guinea and Samoa all indicated that regular germplasm collecting missions had been carried out for traditional crops including bananas, breadfruit, yams, taro and coconuts.

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 CWR. 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 the Islamic Republic of Iran, Pakistan, Syrian Arab Republic, Tunisia and Tajikistan focusing mainly on cereals and legumes. Holdings of plant genetic resources in the national genebank of the Islamic Republic of Iran have doubled since 1996 due to extensive collecting missions conducted in this country. 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 as well as 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 CWR 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. However, this figure probably fails to fully reflect the total number of accessions collected in the almost 200 collecting missions carried out by countries of the region but for which no figures were provided.

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 (CWR, 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, INIBAP/Biodiversity, 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 741,319 accessions of 3,446 species of 612 different genera (see Table 1.1 in Chapter 1).

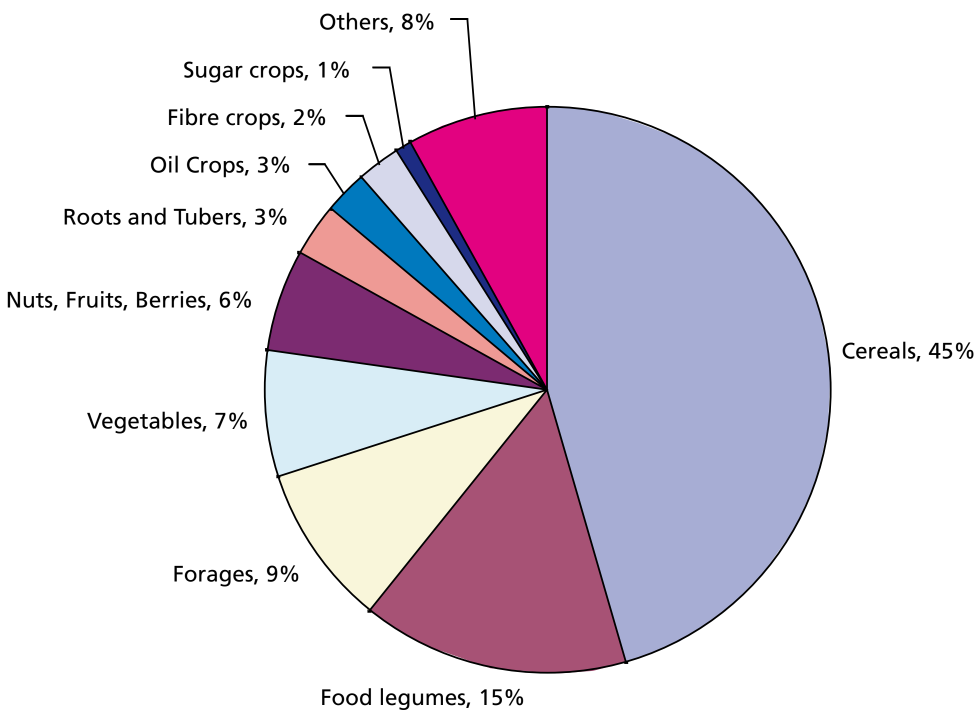
In addition many other international and regional institutions conserve important collections, for example:

- The Asian Vegetable Research and Development Center (AVRDC) maintains about 56,500 accessions of vegetable germplasm;
- The Nordic Genetic Resource Center (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 (ICGT) at the University of the West Indies conserves about 2,300 accessions;
- 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 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, genetic resources are maintained in genebanks at the local and national level by governments, universities, botanical gardens, NGOs, companies, farmers and others in the private and public sectors. They house a wide range of different types of collection: 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 United States of America,[11] 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 the Republic of Korea. The USDA National Plant Germplasm System operates a 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.

FIGURE 3.5
Contribution of major crop groups in total *ex situ* collections



Source: WIEWS 2009

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.

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.[12] 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 137% 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 is impressive, it should be noted, however, that some or even much of this is probably due to an increase in the level of duplication, both planned safety duplication as well as the unplanned, redundant duplication of samples within and among collections. It may also reflect improved data management and reporting.

3.4.2.1 Major crops

Holders of the six largest *ex situ* collections of selected crops are listed in Table 3.2. The largest total number of *ex situ* accessions are of wheat, rice, barley and maize accounting for 76% of the total cereal and pseudo-cereal holdings. Other large cereal holding include sorghum (about 235,000 accessions) and pearl millet (more than 65,000 accessions). In some tropical countries, roots and tubers, including cassava, potato, yam, sweet potato and aroids, are more important as staple foods 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 6,400 accessions) as well as the third largest potato collection (representing about 8% of total world holdings of about 99,000 accessions) after those of INRA-Rennes (France) and VIR (Russian Federation). Other important collections of potato are found at IPK (Germany) and USDA (Sturgeon Bay, United States of America). The largest cassava collection (more than 5,400 accessions) is held by CIAT in Colombia, followed by the collections of Embrapa (Brazil) and IITA (Nigeria).

TABLE 3.2
Holders of the six largest *ex situ* collections of selected crops

Genus (crop)	Total world accessions	Major holders rank 1	%	2	%
Triticum (wheat)	857 940	CIMMYT	13	NSGC (USA029)	7
Oryza (rice)	773 947	IRRI	14	NBPGR (IND001)	11
Hordeum (barley)	470 470	PGRC (CAN004)	9	NSGC (USA029)	6
Zea (maize)	327 931	CIMMYT	8	BPGV-DRAEDM (PRT001)	7
Phaseolus (bean)	262 369	CIAT	14	W6 (USA022)	6
Sorghum (sorghum)	235 711	ICRISAT	16	S9 (USA016)	15
Glycine (soybean)	229 947	ICGR-CAAS (CHN001)	14	SOY (USA033)	9
Avena (oat)	148 260	PGRC (CAN004)	19	NSGC (USA029)	14
Arachis (groundnut)	128 461	ICRISAT	12	NBPGR (IND001)	10
Gossypium (cotton)	104 780	UzRICBSP (UZB036)	11	COT (USA049)	9
Solanum (potato)	99 253	INRA-RENNES (FRA179)	11	VIR (RUS001)	9
Cicer (chickpea)	98 313	ICRISAT	20	NBPGR (IND001)	15
Pisum (pea)	93 977	ATFCC (AUS039)	8	VIR (RUS001)	7
Medicago (medicago)	92 677	AMGRC (AUS006)	30	UzRICBSP (UZB036)	11
Lycopersicon (tomato)	83 680	AVRDC	9	NE9 (USA003)	8
Trifolium (clover)	74 418	WADA (AUS137)	15	AGRESEARCH (NZL001)	9
Hevea (rubber)	73 656	MRB (MYS111)	81	RRII (IND031)	6
Capsicum (capsicum)	73 534	AVRDC	11	S9 (USA016)	6
Prunus (prunus)	69 522	VIR (RUS001)	9	UNMIHT (USA276)	9
Pennisetum (pearl millet)	65 447	ICRISAT	33	CNPMS (BRA001)	11
Vigna (cowpea)	65 233	IITA	24	S9 (USA016)	12
Malus (apple)	60 842	GEN (USA167)	11	VIR (RUS001)	6
Vitis (grape)	59 606	INRA/ENSA-M (FRA139)	9	JKI (DEU098)	6
Lens (lentil)	58 405	ICARDA	19	NBPGR (IND001)	17
Vicia (faba bean)	43 720	ICARDA	21	ICGR-CAAS (CHN001)	10
Aegilops (wheat)	42 026	ICCI-TELAVUN (ISR003)	22	ICARDA	9
Saccharum (sugarcane)	41 128	CTC (BRA189)	12	INICA (CUB041)	9
Cucurbita (cucurbita)	39 584	VIR (RUS001)	15	CATIE	7
Helianthus (sunflower)	39 380	IFVCNS (SRB002)	14	NC7 (USA020)	9
x *Triticosecale* (wheat)	37 439	CIMMYT	46	VIR (RUS001)	5
Ipomoea (sweet potato)	35 549	CIP	18	NIAS (JPN003)	16
Festuca (fescue)	34 204	IHAR (POL003)	14	NIAS (JPN003)	12
Manihot (cassava)	32 450	CIAT	17	CNPMF (BRA004)	9
Dactylis (grasses)	31 541	BYDG (POL022)	19	NGRI (JPN019)	9
Coffea (coffee)	29 807	IRCC/CIRAD (CIV011)	22	IAC (BRA006)	14
Mangifera (mango)	25 653	Ayr DPI (AUS088)	73	CISH (IND045)	3
Beta (sugarbeet)	22 392	W6 (USA022)	11	IPK (DEU146)	10
Elaeis (oil-palm)	21 101	INERA (COD003)	84	MPOB (MYS104)	7
Panicum (millet)	17 634	NIAS (JPN003)	33	KARI-NGBK (KEN015)	13
Dioscorea (yam)	16 446	IITA	20	UNCI (CIV006)	9
Chenopodium (chenopodium)	16 264	BNGGA-PROINPA (BOL138)	27	INIA-EEA.ILL (PER014)	9
Musa (banana)	13 486	INIBAP	9	CIRAD (FRA014)	4
Theobroma (cocoa)	12 373	ICGT	19	CRIG (GHA005)	8
Eragrostis (tef)	8 820	IBC (ETH085)	54	W6 (USA022)	15
Colocasia (taro)	7 284	WLMP (PNG006)	12	RGC (FJI049)	12
Psophocarpus (bean)	4 231	DOA (PNG005)	11	DGCB-UM (MYS009)	10
Corylus (nut)	2 998	COR (USA026)	28	AARI (TUR001)	14
Olea (olive)	2 629	CRA-OLI (ITA401)	17	CIFACOR (ESP046)	12
Bactris (peach palm)	2 593	UCR-BIO (CRI016)	31	CATIE	24
Pistacia (pistachio)	1 168	NPGBI-SPII (IRN029)	29	DAV (USA028)	26

Major holders rank							
3	%	4	%	5	%	6	%
ICGR-CAAS (CHN001)	5	NBPGR (IND001)	4	ICARDA	4	(several)	4
CNRRI (CHN121)	9	NIAS (JPN003)	6	RDAGB-GRD (KOR011)	3	DB NRRC (USA970)	3
CENARGEN (BRA003)	6	ICARDA	6	NIAS (JPN003)	5	IPK (DEU146)	5
NC7 (USA020)	6	ICGR-CAAS (CHN001)	6	INIFAP (MEX008)	4	VIR (RUS001)	3
CNPAF (BRA008)	6	INIFAP (MEX008)	5	IPK (DEU146)	3	ICGR-CAAS (CHN001)	3
ICGR-CAAS (CHN001)	8	NBPGR (IND001)	7	IBC (ETH085)	4	CNPMS (BRA001)	3
RDAGB-GRD (KOR011)	8	AVRDC	7	CNPSO (BRA014)	5	NIAS (JPN003)	5
VIR (RUS001)	8	IPK (DEU146)	3	KARI-NGBK (KEN015)	3	TAMAWC (AUS003)	2
S9 (USA016)	8	BBC-INTA (ARG1342)	6	ICRISAT (NER047)	6	ICGR-CAAS (CHN001)	5
CICR (IND512)	9	ICGR-CAAS (CHN001)	7	VIR (RUS001)	6	IRCT-CIRAD (FRA002)	4
CIP	8	IPK (DEU159)	5	NR6 (USA004)	5	NIAS (JPN003)	3
ICARDA	13	ATFCC (AUS039)	9	W6 (USA022)	6	NPGBI-SPII (IRN029)	6
ICARDA	7	IPK (DEU146)	6	W6 (USA022)	6	IGV (ITA004)	4
ICARDA	10	W6 (USA022)	8	INRA CRRAS (MAR088)	4	VIR (RUS001)	3
IPB-UPLB (PHL130)	6	IPK (DEU146)	5	VIR (RUS001)	3	NIAS (JPN003)	3
ICARDA	6	WPBS-GRU-IGER (GBR016)	6	SIAEX (ESP010)	5	W6 (USA022)	5
IDEFOR-DPL (CIV061)	3	FPC (LBR004)	2	IAC (BRA006)	1	RRI (VNM009)	1
INIFAP (MEX008)	6	NBPGR (IND001)	5	IAC (BRA006)	3	NIAS (JPN003)	3
CRA-FRU (ITA378)	3	EFOPP (HUN021)	3	AARI (TUR001)	3	(several)	2
NBPGR (IND064)	9	ORSTOM-MONTP (FRA202)	7	PGRC (CAN004)	6	ICRISAT (NER047)	4
CENARGEN (BRA003)	8	LBN (IDN002)	6	NBPGR (IND001)	5	ICGR-CAAS (CHN001)	4
NIAS (JPN003)	4	NFC (GBR030)	4	PSR (CHE063)	3	(several)	3
RAC (CHE019)	5	DAV (USA028)	5	IVM (UKR050)	4	CRA-VIT (ITA388)	4
ATFCC (AUS039)	9	NPGBI-SPII (IRN029)	5	W6 (USA022)	5	VIR (RUS001)	4
ATFCC (AUS039)	6	IPK (DEU146)	4	INRA-RENNES (FRA010)	4	UC-ICN (ECU003)	4
NPGBI-SPII (IRN029)	6	NIAS (JPN003)	6	VIR (RUS001)	5	NSGC (USA029)	5
WICSBS	8	NIAS (JPN003)	7	MIA (USA047)	6	GSC (GUY016)	5
CENARGEN (BRA003)	5	ICGR-CAAS (CHN001)	4	INIFAP (MEX008)	4	NIAS (JPN003)	3
ICGR-CAAS (CHN001)	7	INRA-CLERMON (FRA040)	6	CNPSO (BRA014)	6	VIR (RUS001)	4
NSGC (USA029)	5	SCRDC-AAFC (CAN091)	5	LUBLIN (POL025)	5	IR (UKR001)	5
S9 (USA016)	3	MHRP (PNG039)	3	CNPH (BRA012)	3	BAAFS (CHN146)	2
W6 (USA022)	7	IPK (DEU271)	6	WPBS-GRU-IGER (GBR016)	4	LRS (CAN041)	3
IITA	8	ICAR (IND007)	4	NRCRI (NGA002)	4	SAARI (UGA001)	4
IPK (DEU271)	6	W6 (USA022)	5	WPBS-GRU-IGER (GBR016)	3	AGRESEARCH (NZL001)	2
CIRAD (FRA014)	13	CATIE	6	ECICC (CUB035)	5	JARC (ETH075)	4
HRI-DA/THA (THA056)	1	MIA (USA047)	1	ILETRI (IDN177)	1	NUC (SLE015)	1
IFVCNS (SRB002)	10	INRA-DIJON (FRA043)	7	ICGR-CAAS (CHN001)	6	(several)	6
CPAA (BRA027)	3	ICA/REGION 5 (COL096)	1	IOPRI (IDN193)	1	NUC (SLE015)	1
S9 (USA016)	4	CN (CIV010)	3	CIAT	3	ORSTOM-MONTP (FRA202)	3
UAC (BEN030)	7	PGRRI (GHA087)	6	DCRS (SLB001)	3	PU (LKA002)	3
IPK (DEU146)	6	DENAREF (ECU023)	4	UBA-FA (ARG1191)	3	U.NACIONAL (COL006)	2
DTRUFC (HND003)	4	QDPI (AUS035)	3	CNPMF (BRA004)	3	CARBAP (CMR052)	3
CEPEC (BRA074)	6	CORPOICA (COL029)	6	CATIE	6	(several)	6
KARI-NGBK (KEN015)	12	NIAS (JPN003)	4	NBPGR (IND001)	3	CIFAP-CAL (MEX035)	3
MARDI (MYS003)	9	NBPGR (IND024)	6	HRI-DA/THA (THA056)	6	PRC (VNM049)	5
TROPIC (CZE075)	10	IDI (LKA005)	9	LBN (IDN002)	9	(several)	6
KPS (UKR046)	6	HSCRI (AZE009)	6	IRTAMB (ESP014)	4	UzRIHVWM (UZB031)	4
NPGBI-SPII (IRN029)	9	DAV (USA028)	5	HSCRI (AZE009)	5	AARI (TUR001)	5
IAC (BRA006)	13	CORPOICA (COL029)	10	EENP (ECU022)	6	INRENARE (PAN002)	3
IRTAMB (ESP014)	9	GRI (AZE015)	5	ACSAD (SYR008)	4	CSIRO (AUS034)	4

The genebanks of the CGIAR Centres generally represent the major repositories for germplasm of their mandate crops. For example: the world's major wheat (13% 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 (16%), pearl millet (33%), chickpea (20%) and groundnut (12%). ICARDA houses the world's largest collections of lentil (19%), faba bean (21%) and vetches (16%). 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 9% and CRA-FRU in Italy 3% of the total. *Malus* and *Vitis* species are represented by second and third largest number of accessions, respectively. The largest collections of apple being held by USDA in Geneva, Cornell University, and VIR (Russian Federation). INRA/ENSA-M in France (9%) and JKI in Germany (6%) hold the largest collections of grape. After Bioversity International's *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 of 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 and INIFAP in Mexico.

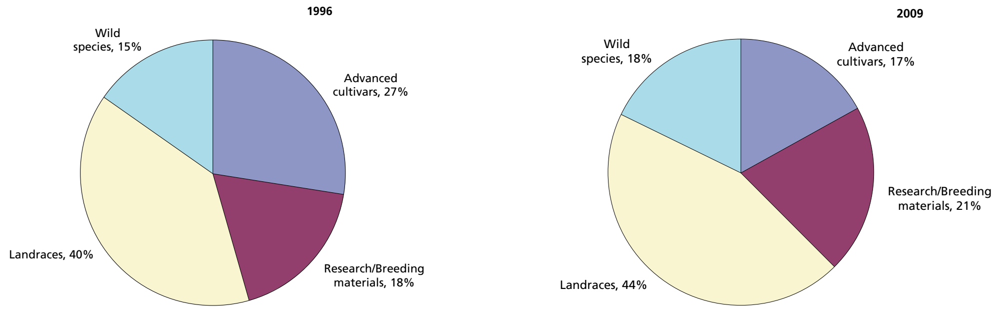
Australia is the predominant holder of forage legume germplasm, with 30% of the world holdings of *Medicago* at AMGRC and 15% of the world's clover holdings at WADA. The most important temperate forage grasses include *Festuca*, *Dactylis* and *Lolium* (approximately 92,000 accessions among them). Some of the largest collections of these are held in Poland, Japan 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 50,000 accessions globally and sunflower almost 40,000. The largest single collections of these are held by India (17%) and Serbia (14%), respectively.

Cotton is the most important fibre crop in terms of the total number of accession held, with more than 104,000 accessions being maintained worldwide. Of these, 11% are held in Uzbekistan at UzRICBSP. Of the more than 70,000 accessions of rubber, 81% 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 ICGT at the University of the West Indies in Trinidad and Tobago (19%).

3.4.2.2 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 under-utilizes crops. In the case of yam, for example, the number of conserved accessions has increased from 11,500 in 1995 to 16,400 in 2008, and in bambara groundnut from 3,500 in 1995 to 6,100 in 2008. This increased 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 CWR whose natural habitats are

FIGURE 3.6
Types of accessions in *ex situ* germplasm collections in 1996 and 2009 (the size difference in the charts represents the growth in total numbers of accessions held *ex situ* between 1996 and 2009)



Source: WIEWS 1996 and 2009

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

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

Commodity group	No. of accessions	% Wild species	% Landraces	% Breeding materials	% Advanced cultivars	% Others
Cereals	3 182 020	5	29	15	8	43
Food legumes	1 070 258	4	32	7	9	49
Roots and tubers	206 002	10	30	12	10	37
Vegetables	502 817	5	22	8	14	51
Nuts, fruits, berries	423 003	7	13	14	21	45
Oil crops	184 384	7	21	15	11	46
Forages	654 529	34	13	3	4	45
Sugar crops	63 520	7	7	11	25	50
Fibre crops	168 997	4	18	10	10	57
Medicinal, aromatic, spice and stimulant crops	159 434	13	24	7	9	48
Industrial, ornamental plants	152 322	46	1	2	4	47
Other	262 946	29	4	2	2	64
Total/overall mean	**7 030 232**	**10**	**24**	**11**	**9**	**46**

Source: WIEWS 2009

conserved *ex situ*. Of these, about 17% are advanced cultivars, 22% breeding lines, 44% landraces and 17% wild or weedy species.[13] 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 improvement programmes.

Table 3.3 provides a breakdown of type of accession by crop group. 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.

3.4.4 Source of material in genebanks

About 55% 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 sub-regional basis.

The percentage of indigenous accessions is greatest for Southern Africa, West Asia 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

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(*)	% of indigenous accessions
Africa	West Africa	32 544	40 406	81
Africa	Central Africa	934	18 829	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	180 604	80
America	Central America and Mexico	41 370	51 513	80
America	Caribbean	13 746	23 671	58
America	North America	117 015	524 605	22
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	74 466	137 763	54
Asia and the Pacific	Pacific	42 649	188 988	23
Europe	Europe	353 138	938 051	37
Near East	South/East Mediterranean	66 363	73 428	90
Near East	West Asia	54 735	55 255	99
Near East	Central Asia	20 375	25 283	81
World		**1 702 760**	**3 118 762**	**55**

(*) Total number of accessions whose country of origin is reported. *Source:* WIEWS 2009 appears 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, Ethiopia 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 Viet Nam while in Cook Islands, Fiji and Palau they are exclusively so. In China 82% of materials in seed collections are reportedly indigenous, while at NIAS in Japan native accessions are about 39% of the total conserved.

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 five times and more than once respectively, the number of foreign accessions compared to native ones. According to the USDA GRIN database, native accessions comprise about 16% of the total germplasm conserved in the United States of America's National Plant Germplasm System.

A wide range in origins of germplasm is reported in European genebanks. More than 75% of germplasm holdings stored in Greece, Romania, Portugal and Spain, are indigenous, as are those conserved at NordGen, originating in the five countries served by the genebank. However, the percentage of indigenous accessions in the national genebanks of Bulgaria, Germany, Netherlands, Czech Republic and Russian Federation varies between 14 and 20%. Austria, France, Hungary, Italy, Poland and Ukraine conserve more foreign germplasm than native.

In the Near East region, either all or 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 it varies considerably according to crop and according to the perceptions of different stakeholder groups. Over recent years, the GCDT has supported the development of a number of crop and regional conservation strategies.[14] 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 critical 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 *Musa 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 redundancy 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 storage of seeds, whole plants and tissues, isolated DNA can be 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[15] 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[16,17] 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, as a safety net for *ex situ* seed collections of the world's crops. This is the 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 GCDT and the Nordic Genetic Resource Center. The seed vault opened in early 2008 and as of June 2009 housed more than 412,000 accessions, all of which were 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, who is responsible for the periodic monitoring of viability and regeneration of accessions deposited at SGSV. Details of the collections deposited in SGSV are provided in Table 3.5.

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, Ghana, Kenya, Mali, Nigeria and Uganda reported having *in vitro* storage facilities. No country specified having an ability to conserve germplasm

TABLE 3.5
Germplasm holdings at Svalbard Global Seed Vault as of 18 June 2009

Depositor	Number of			
	Genera	*Species*	*Accessions*	*Countries of origin*
Centre for Genetic Resources (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 Federation)	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 (Philippines)	3	4	500	16
National Plant Germplasm System (United States of America)	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 (United States of America)	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 (former countries denominations e.g. Soviet Union are also counted); undetermined genera and species are not counted. (Elaborated from http://www.nordgen.org/sgsv)

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 the loss of its entire *ex situ* collection as a result of a failure in the electricity 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 used 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.

In North America, both the United States and Canada operate long- and medium-term conservation genebanks, including cryopreservation facilities.

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 155,000 accessions in genebanks (seed and field collections), of which 3,200 *in vitro*. Belgium, too reported substantial numbers of *in vitro* accessions (more than 1,500), largely as a result of 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 conserve their genetic resources under ambient or medium-term conservation conditions (5-10°C with no relative humidity control). While several countries in this region have no genebank some, 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.

IARCs Genebanks

Since the publication of the first SoW report 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 projects to upgrade the standards of all the 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 projects also funded the 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 also identified as significant constraints in the first SoW report.

Although a substantial number of the world's collections are partly or entirely duplicated in more than one genebank, it is often not possible with current data and information to identify the same accession in different genebanks and to clearly distinguish between safety and redundant duplicates. 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 worldwide are 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 120,000 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 GCDT in the process of developing the Barley Crop Strategy.[18] 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. CWR, 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 CGRFA invited countries to report if there are important risks to *ex situ* genetic resources in their national collections, as part of an international Early Warning System.

In the late 1990s, the Russian Federation alerted the CGRFA the difficulties the Vavilov Institute was facing at that time.

Since the publication of the first SoW report, a major step forward in ensuring the safety of collections has been the establishment of the GCDT,[19] described elsewhere in this report (see section 6.5). The GCDT 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 Centres. 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 the NCGRP of USDA. 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 rice collections. Other IARCs 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. The Nordic countries, Denmark, Finland, Iceland, Norway and Sweden, all reported having secured their accessions through depositing duplicate samples in Denmark as well as 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 the Islamic Republic of 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, infrastructure 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 GCDT have highlighted the fact that regeneration backlogs occur in all types of conserved germplasm and in all regions.[20] According to information on NISMs databases,[21] 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 by crop experts as being of highest priority.

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 United Republic of Tanzania also warned about a decreasing capacity to manage regeneration that has 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. Viet Nam 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 (Viet Nam), while for cross-pollinated species by DOR (India) and PCA-ZRC (Philippines). China reported regeneration activities that addressed more than 286,000 accessions and the 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 by 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, the Islamic Republic of 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 while the other genebanks in these countries have only carried out regeneration to a more limited extent. There is a need to regenerate the entire wheat collections held in the national genebanks of Azerbaijan, Tajikistan and Turkmenistan.[22]

3.8 DOCUMENTATION AND CHARACTERIZATION

3.8.1 Documentation

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. A number of national genebanks have published collection data on the web or are in the process of doing so, often with the facility of being able to order 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, at least partly, documented only on paper (16 countries) and/or in spreadsheets (32 countries).[23] Dedicated information management systems are used to manage passport and characterization data on *ex situ* collections 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 through the sharing of experiences and tools.

Almost all the CGIAR Centres 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.[24]

The Crop Strategies[25] sponsored by the GCDT contain information relevant to the state of 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 passport information as well as characterization data. However, the major problem is the lack of standardization among systems. A similar problem exists 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 there is a lack of electronically available evaluation data.

Electronic documentation of potato accession worldwide is only partially complete and few genebanks are able to provide characterization and evaluation data through their own websites. For sweet potato a similar situation exists and inadequate documentation and characterization information and is available, particularly in Africa. For banana, however, the research community is well served regarding information and there is an effective information 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 recorded and standardized, electronic global information systems are needed for most collections.

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 reported having characterization and evaluation data on their collections, but with some exceptions (e.g. most SADC countries, Ethiopia, Kenya and Mali), it was generally incomplete and not standardized. Togo indicated that its documentation was in a rudimentary state and several other countries reported serious weaknesses. 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 reported that they still maintain some records on paper and eight use spreadsheets, at least eight others have dedicated electronic systems[26] and Kenya, Ghana and Togo reported using generic databases to manage information on *ex situ* collections.

Americas

A significant amount of information is publicly available on the *ex situ* holdings in North America. Passport information is freely accessible through the web-based GRIN[27] on more than half a million accessions of about 13,000 species stored in 31 genebanks 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.[28]

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. DBGERMO, developed by INTA, Argentina, is a dedicated germplasm data management system that is popular in the region, being used in Argentina, Chile, Ecuador, Paraguay, Uruguay and by CATIE in Costa Rica. Paraguay expressed the need for DBGERMO to be adopted at a regional level in order to harmonize data collection and retrieval. SIBRAGEN is the documentation and dissemination system in use by Embrapa in Brazil. GIS for the geographical analysis of collected materials are reportedly used in Argentina and Ecuador.

In their country reports, most countries in 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. 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 and Tobago, and by the genebank at CATIE in Costa Rica. Some genebanks in Mexico still use paper records 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. 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 GIS and together with Bangladesh, Thailand and Viet Nam recognized the need for a nation-wide *ex situ* germplasm information system. Significant advances in making information on *ex situ* holdings publicly available were reported by Japan and the Republic of Korea including passport and characterization data on more than 87,000 accessions held at the National

Institute of Agrobiological Resources in Japan[29] and passport data on about 20,000 accessions at the National Agrobiodiversity Centre in the Republic of Korea.[30]

Country reports from the Pacific suggested that relatively little comprehensive documentation work has been done in this region. 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 the development of a database was a national priority. Efforts to increase the availability of data on *ex situ* collections have been undertaken by Australia and New Zealand through web-based systems. AusPGRIS[31] at present includes passport data on about 40,000 accessions from 229 genera stored at Biloela of the Queensland Department of Primary Industries, and the web sites of the Margot Forde Forage Germplasm Centre[32] and the Arable crop genebank and online database.[33]

Europe

The state of documentation is generally good across Europe, according to the country reports. Nonetheless a variety of tools are used for data storage and management, among which spreadsheets and generic databases are the most common. Standardized passport data from 38 countries are published by EURISCO,[34] a centralized web-based catalogue managed by Bioversity International since 2003 under the ECPGR. The network has also supported the establishment and maintenance of European Central Crop Databases that compile and disseminate characterization and evaluation data on several crops. The Nordic countries have standardized their approach to documentation and characterization and provide information through NordGen using the Sesto system,[35] Macedonia reported that it was ready to adopt the same information system. Croatia reported not yet having compiled characterization data, although passport data were recorded for most accessions.

Near East

Good progress has been made since 1996 on documenting accessions held in the main genebanks. Egypt, Jordan, Morocco, Pakistan, the Syrian Arab Republic and Turkey all reported that their germplasm information is now fully maintained in a dedicated system 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 the recording of characterization and evaluation data electronically for more than 60% of the *ex situ* cereal accessions and 50% of the fruit and fiber accessions[36]. Passport data for some accessions from Cyprus are also recorded in EURISCO. 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.[37] Iraq and Kazakhstan reported using crop registers in paper format and Tajikistan reported that a joint computerized system was being developed with Kyrgyzstan. Egypt maintains documentation on all germplasm accessions and has substantial amounts of data on morphological and molecular characteristics as well as on agronomically important traits.

3.8.2 Characterization

In 1996 the GPA highlighted the importance of characterization both as a way to help link the conservation of PGRFA with its use, as well as to facilitate the identification of gaps in collections and the development of core collections. Since then, in spite of the considerable work on characterization reported by many genebanks and associated programmes, often involving regional and international collaboration (see Chapter 6), overall, the information produced has been underused due largely to a lack of standardization and to accessibility constraints. Many country reports indicated that the lack of readily available characterization and evaluation data is a major limitation to the greater use PGRFA in breeding programs.

An indication of the level of characterization of the collections held by international centres is reported in Table 3.6

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.

Africa

In most African nations there has been an increase in the morphological characterization of materials in *ex situ* collections since the publication of the first SoW report. The work has mostly been carried out by national PGRFA centres and programmes, sometimes in collaboration with research institutes and universities. 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%)[40] and Senegal's collection of groundnut (100%). Ninety percent of Ghana's important cocoa collection is characterized for morphological traits, 10% using molecular makers, and 80% has been evaluated agronomically and for biotic stresses.[41] 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

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[38]	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

TABLE 3.7
Average extent of characterization and evaluation of national collections in 40 countries[39]

Crop Groups	Percent of germplasm holdings					Total number of	
	Characterized	Evaluated					
	Morphologically	*Agronomically*	*Biochemically*	*for abiotic factors*	*for biotic factors*	*Accessions*	*Reporting countries*
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 reports that a considerable amount of work is still needed in most countries and capacity particularly for new molecular techniques is still far from adequate.

Americas

In South America many countries reported having recorded characterization data on a range of morphological, agronomic, molecular and biochemical traits. In Argentina, Bolivia, Ecuador and Peru a large proportion of total *ex situ* holdings has been morphologically characterized and almost half evaluated for agronomically important traits including tolerance to environmental and other stresses. 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.[42] Mexico reported morphological and agronomic characterization for 46% of accessions and Nicaragua for 100%. Within the Caribbean, Saint Vincent and the Grenadines said that characterization and evaluation were rarely carried out, but Trinidad and Tobago reported considerable progress in this area.

Asia and the Pacific

In their country reports all Asian countries indicated that morphological characterization and agronomic evaluation data were widely available; for example Japan has compiled a full complement of characterization data, and in India characterization and evaluation data are available on 74% and 73% respectively of the national germplasm collections. The equivalent figures for Philippines are 40% and 60% respectively. While India reported that it has 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 of food legume and cereal crops. A number of countries including Malaysia, Philippines and Thailand also reported using biochemical markers. In the Pacific, characterization based on morphological, agronomic and molecular traits was reported for taro by Fiji, Palau, and Samoa.

Europe

According to the country reports, the state of characterization has generally improved across Europe since the first SoW report was published. For example, at the Institute for Agrobotany in Hungary, approximately 90% of the accessions of cereals and legumes, 50% of the root and tubers, 75% of the vegetables, 80% of the forages and 30% of the underused crops have now been characterized and evaluated. The Czech Republic reported relatively comprehensive data on morphological and agronomically important traits including abiotic and biotic stresses, on its collections of fruit trees, wheat, barley, peas and soybean. In Romania, about 20% of the total holdings in the national genebank have been phenotypically characterized and biochemically evaluated. Albania reported on its extensive use of morphological and agronomic descriptors but indicated that, with few exceptions, the characterization data are not readily accessible.

Near East

The characterization and evaluation of genetic resources using standard descriptors have advanced in almost all countries of the region since the publication of the first SoW report.

Characterization has been carried out on a wide range of species for morphological traits of agronomic importance, quality attributes and for tolerance and resistance to biotic and abiotic stresses. Several countries, for example Egypt, the Islamic Republic of Iran, Jordan, Morocco, Pakistan, the Syrian Arab Republic, Tunisia and Turkey also reported that they had undertaken molecular characterization, largely through academic studies. Molecular characterization of date palm has been carried out in Kuwait, Qatar, Saudi Arabia and United Arab Emirates.

3.9 GERMPLASM MOVEMENT

Information on germplasm movement provides a valuable indicator of the use of plant genetic resources (see Chapter 4). However, such information is often not recorded and only limited data were provided in the country reports. However, there is now more information available on this 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 or providing 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 one aspect of germplasm exchange; sources of germplasm for use in plant breeding programmes.

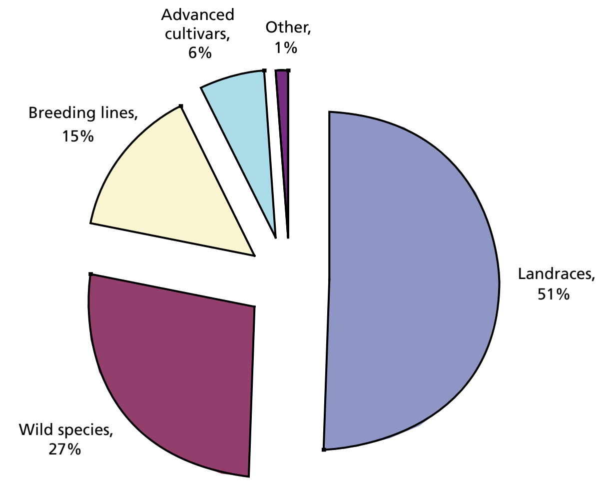
The ability of a potential recipient to access a particular accession is often limited by the size of a stored sample and its phytosanitary status (see Chapter 7). Furthermore, inadequate information systems often make it difficult to access the same accession from an alternative source.

Comprehensive data on germplasm acquisition and distribution are readily available only for the genebanks of the IARCs. 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 was similar to the period from 1993 to 1995 as reported in the first SoW report.

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.

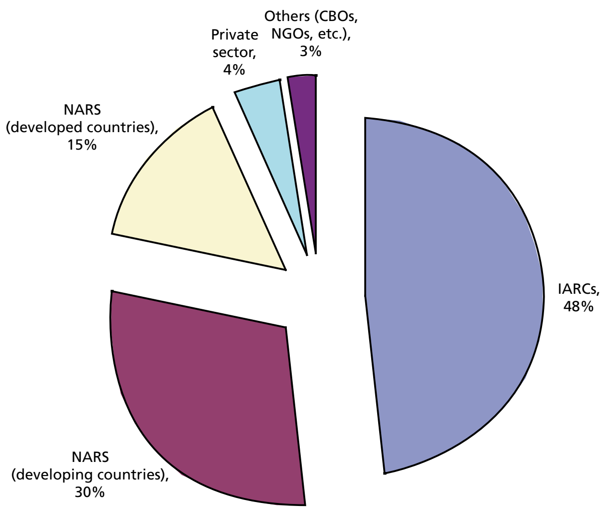
Figure 3.8 shows the distribution of germplasm by the IARCs to different types of recipient organization. Nearly half the germplasm was distributed within or between the Centres themselves and 30% went to developing country NARS. Developed country NARS received 15% and the private sector 3%. Breeding materials and advanced cultivars went mainly to NARS in developing countries, whereas developed country NARS requested mainly landraces. Wild species were requested equally by most types of organization.

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
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

Little data on germplasm movement was provided in the country reports 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 a five year period. In its country report, Ethiopia estimated that an average of 5,000 samples were distributed annually to national programmes.

Asia and the Pacific

Little detailed information on germplasm movement was also reported from Asia, but China has distributed 212,000 accessions since 1998, 95% of which were within the country. India has distributed more than 164,000 accessions over the past ten years while Pakistan, since 1996, has supplied some 13,000 samples to national institutions and more than 5,000 to international organizations. Japan distributed more than 36,000 samples in country and about 1,300 abroad over the period 2003-2007.

Europe

The extent of germplasm movement in Europe and the availability associated data varied considerably among countries. While Romania also reported little movement of germplasm, Germany reported 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 elsewhere. However it is difficult to assess the importance of farmer-farmer exchanges in relation to the overall distribution of genetic diversity nationally, regionally and internationally. 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. 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).[43] As well as their living collections, botanical gardens often have herbaria and carpological collections, and an

TABLE 3.8
Botanical garden collections of selected crops listed in Annex 1 of the ITPGRFA[47]

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 tuberosum*	190
Sorghum	*Sorghum*	15
Wheat	*Triticum aestivum*	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

increasing number have seed banks and *in vitro* collections. In general, botanical gardens focus on conserving interspecific diversity of flora and thus tend to maintain a large number of species with relatively few accessions for each species.

Over the last ten years, the number of botanical gardens recorded in Botanic Gardens Conservation International's global database increased from 1,500 to more than 2,500,[44] at least partly reflecting the current interest in 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 75 botanical gardens, Germany 95, Italy 102, Mexico 30 and Indonesia 12. Most other countries, however, reported having less than ten. Botanical gardens often maintain very substantial germplasm holdings although only a percentage of these are important for food and agriculture. The German botanical gardens together conserve about 300,000 accessions of 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 species found in the native wild flora (as mentioned in 19 country reports), especially those under threat of extinction. Many of these species are either of direct socio-economic or cultural importance to local communities or in some cases are crop wild relatives; both are groups that tend to be less well represented in traditional collections of PGRFA.

The GSPC[45] adopted by the CBD in 2002 includes some measurable targets for conserving plants. 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. 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.[46]

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.[48]

3.10.2 Documentation and germplasm exchange

The global PlantSearch database maintained by BGCI includes some 575,000 records on around 180,000 taxa[49] in cultivation in about 700 botanical gardens worldwide. However, this information consists of species names only and does not include descriptive information or the 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-level information. These include PlantCol in Belgium,[50] SysTax in Germany,[51] and the Dutch National Plants Collection.[52] In the United States of America, the Plant Collections Consortium aims to bring together information on collections in 16 United States of America institutions and 4 international institutions.[53] In the United Kingdom, 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.[54]

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 United States of America. 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.[55]

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 CWR 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 under-utilized 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 largely as a result of funding provided to the CGIAR Centres for the 'Global Public Goods' project, and at the national level in part as a result of a funding by the GCDT. However, much more remains to be done;
- Documentation and characterization data on collections have progressed somewhat, although there are still large data gaps and much of the existing data is not accessible electronically;
- The number of botanical gardens around the world now in exceeds 2,500, maintaining samples of some 80,000 plant species, including CWR. Botanical gardens took the lead in developing the Global Strategy for Plant Conservation adopted by the CBD in 2002;
- The GCDT, founded in 2004, represents a major step forward in underpinning the world's ability to secure PGRFA in the long-term;
- With the establishment of the highly innovative SGSV, 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 and action. Continuing gaps and needs include:

- Many countries, although aware of the importance of collecting, conserving, regenerating characterizing, documenting and distributing plant genetic resources, 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 under-utilized species and CWR, 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] World Information and Early Warning System (WIEWS). Available at: http://apps3.fao.org/wiews
[2] WIEWS. Available at: http://apps3.fao.org/wiews
[3] Country Reports: Brazil, India, China, Japan, Mexico, Russian Federation and United States of America.
[4] The Svalbard Global Seed Vault. See section 3.2 for further information.
[5] Excluding specialized genebanks only holding genetic stocks of plants that are not for food and agriculture.
[6] Country grouping by region and subregion as per Appendix 1 of the first State of the World's Plant Genetic Resources for Food and Agriculture.
[7] More than 41 countries that reported undertaking collecting missions since 1996 did not provide figures on the number of accessions collected.
[8] Collecting of duplicate samples derived from joint missions are included.
[9] **Spooner, D.M. and William, K.A.** 2004. Germplasm acquisition. *Encyclopedia of Plant and Crop Science*. New York, Marcel Dekker Inc.
[10] Crop Strategy Documents. For details see: http://www.croptrust.org/main/strategy.php
[11] NCPGR holds the USDA base collection, including 76 percent of the duplicate material under the National Plant Germplasm System (NPGS).
[12] Among these are: Argentina, Bolivia, Brazil, Uruguay and Venezuela.
[13] 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.
[14] Crop Strategies. Available at: http://www.croptrust.org/main/strategy.php
[15] **de Vicente, C. and Andersson, M.S**. (Eds.) 2006. DNA banks - providing novel options for genebanks? Bioversity International (formerly IPGRI), Rome. Available at: http://books.google.com/books?id=B8Of_QoxRXEC
[16] **Engelmann, F.** 2004. Genetic Resource Conservation of Seeds. *Encyclopedia of Plant and Crop Science*. New York, Marcel Dekker Inc.
[17] **Gómez-Campo, C**. 2007. A guide to efficient long term seed preservation. Monographs ETSIA, Universidad Politécnica de Madrid 170: 1-17.
[18] Global strategy for the *ex situ* conservation and use of barley germplasm. 2008. Available at: http://www.croptrust.org/documents/web/Barley_Strategy_FINAL_27Oct08.pdf
[19] The Global Crop Diversity Trust. Available at: www.croptrust.org
[20] **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. Available at: http://www.croptrust.org/documents/WebPDF/Crop%20and%20Regional%20Conservation%20Strategies%20Review.pdf
[21] National Information Sharing Mechanisms on PGRFA from 47 countries and based on replies from 240 genebanks. Available at: www.pgrfa.org/gpa
[22] International Maize and Wheat Improvement Center (CIMMYT). 2007. Global strategy for the *ex situ* conservation with enhanced access to wheat, rye and triticale genetic resources. Available at: http://www.croptrust.org/documents/web/Wheat-Strategy-FINAL-20Sep07.pdf
[23] 115 stakeholders from 32 countries reportedly store *ex situ* holdings information in MS Excel (NISMs). Available at: www.pgrfa.org/gpa
[24] System-wide Information Network for Genetic Resources. Available at: http://singer.cgiar.org/
[25] See various Crop Strategy Documents for details.
[26] Ethiopia and SADC countries.
[27] Available at: http://www.ars-grin.gov/
[28] Available at: http://pgrc3.agr.gc.ca/search_grinca-recherche_rirgc_e.html
[29] Available at: http://www.nias.affrc.go.jp/index_e.html
[30] Available at: http://genebank.rda.go.kr/
[31] Available at: http://www2.dpi.qld.gov.au/extra/asp/auspgris/
[32] Available at: http://www.agresearch.co.nz/seeds/default.aspx
[33] Available at: http://www.crop.cri.nz/home/research/plants/genebank.php
[34] Available at: http//: www.ecpgr.cgiar.org/Networks/NCG
[35] Available at: http://tor.ngb.se/sesto/
[36] Available at: http://www.pgrfa.org/gpa/aze
[37] Available at: http://www.fao.org/hortivar
[38] Information for the wheat collection held at CIMMYT is not available.

[39] Country Reports: Argentina, Armenia, Azerbaijan, Benin, Bolivia, Chile, Congo, 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, Tajikistan, Thailand, Togo, Uruguay, Uzbekistan, Venezuela, Viet Nam and Zambia.

[40] Available at: http://www.pgrfa.org/gpa/eth and http://www.pgrfa.org/gpa/mli

[41] Available at: http://www.pgrfa.org/gpa/gha

[42] Available at: http://www.pgrfa.org/gpa/cub

[43] 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

[44] BGCI 2009. Available at: http://www.bgci.org/garden_search.php

[45] Convention on Biological Diversity (CBD). 2002. Global Strategy for Plant Conservation (GSPC). Secretariat of the Convention on Biological Diversity, Montreal, Canada.

[46] Information from BGCI's PlantSearch database.

[47] **Sharrock, S. and Wuse Jackson, D**. 2008. The role of botanical gardens in the conservation of crop wild relatives. *In*: Maxted, N, Ford-Lloyd, B.V., Kell, S.P., Iriondo, J.M., Dulloo, M.E. and Turok, J. (Eds.). Crop wild relative conservation and use. CAB International, Wallingford, UK.

[48] Further information available at: www.ensconet.eu

[49] Data correct as at March 2009.

[50] Available at: www.plantcol.be/index.php

[51] Available at: www.biologie.uni-ulm.de/systax/

[52] Available at: www.nationale-plantencollectie.nl/

[53] Available at: www.PlantCollections.org

[54] Further information available at: http://epic.kew.org/index.htm

[55] Further information available at: 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, the 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.

Of course PGRFA also have many other uses including direct introduction for production on farm, education and scientific research on topics ranging from crop origins to gene expression. 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 for such uses is increasing, this chapter will concentrate mainly on what remains its primary use; breeding new crop varieties and their dissemination to farmers. It provides an overview of the current state of PGRFA use, with special attention being 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 changes that have taken place since the first SoW report was published is given and major gaps and needs for the future are identified.

4.2 GERMPLASM DISTRIBUTION AND USE

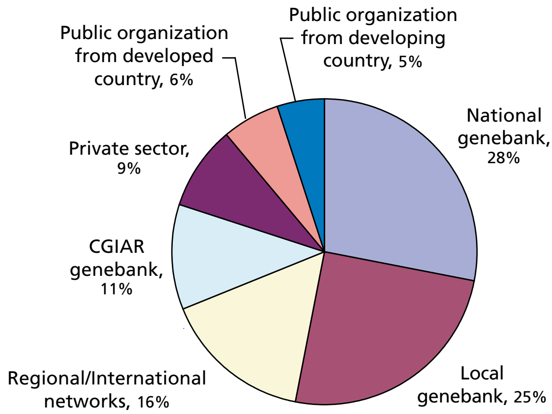
Data on the dissemination of germplasm from genebanks provides an indication of trends in the use of PGRFA by different groups. Table 4.1 shows PGRFA movement from the

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	194 546	51
Wild species	29.2	19.0	40.5	7.1	19.1	104 982	27
Breeding lines	8.5	23.1	5.4	36.0	6.5	56 804	15
Advanced cultivars	3.5	8.0	9.1	5.1	8.6	24 172	6
Others	0.9	1.4	0.1	0.1	0.1	3 767	1

Source: Survey carried out by the System-wide Genetic Resources Programme (SGRP) of the IARCs. The information was provided by genebank managers and is not consistent among genebanks with respect to the inclusion or absence of data on material distributed by breeders through their networks.

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



[a] *Source:* National Information Sharing Mechanism 2008 (available at: 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.

IARCs 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.

Comprehensive information on germplasm distribution by national genebanks for a given period is seldom available in the country reports. However, Japan reported 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 (1,299) and the private sector (995). The report from Poland indicated that the number of accessions sent out in 1997 and 2007 was very similar (approx. 5,700); nevertheless there was a significant increase in 2002 when about 10,000 accessions were distributed.

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, as indicated in Figure 4.1, national plant breeding programmes make reasonable use of the genetic resources stored in genebanks.

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 measured or assessed and expressed equally 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 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 a greater use of PGRFA 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 and more readily available data, on 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 CWR. Thailand was one of few countries that reported carrying out economic evaluation of its accessions. China called for better evaluation standards, while 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 has gone into characterizing morphological and agronomic traits and that molecular markers have been relatively little used outside the Near East. Abiotic and biotic stresses received roughly equal attention.

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 the topic was not covered in the first SoW report, many country reports pointed out the value of well-documented core and mini-core collections to plant breeders,[2] and several suggested it would be useful to expand the

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

Region	No.[a]	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

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.

[a] Total number of *ex situ* collections surveyed for which characterization data exist.

number of core collections to cover more crops than at present. Other countries, however, did not consider them useful.[3] Bangladesh stated that there was only limited knowledge about core collections in the country 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 could 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 Russian Federation 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.

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 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 GCDT, and the Generation Challenge Programme (GCP) 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

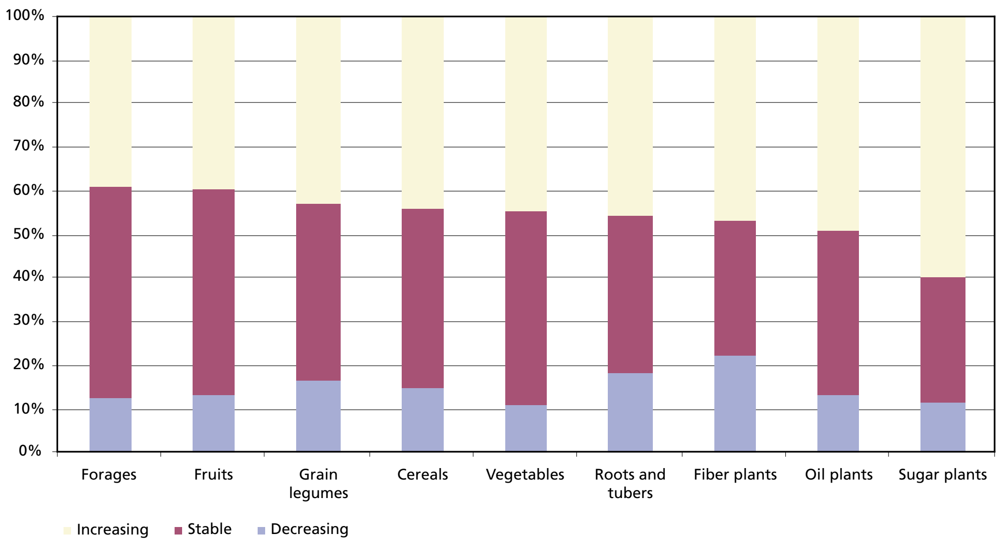
TABLE 4.3
Major obstacles to the establishment of core collections: percentage of respondents in each region who indicated that a particular constraint represented an important constraint in the region

Region	Funds	Lack of personnel	Limited no. accessions	Need not recognized	Limited information on accessions	Poor access to germplasm	Method 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

Source: National Information Sharing Mechanism 2008 (available at: 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.

of plant breeders to assemble genes for the desired traits within new varieties. Recognizing the importance of plant genetic improvement, 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 over 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

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



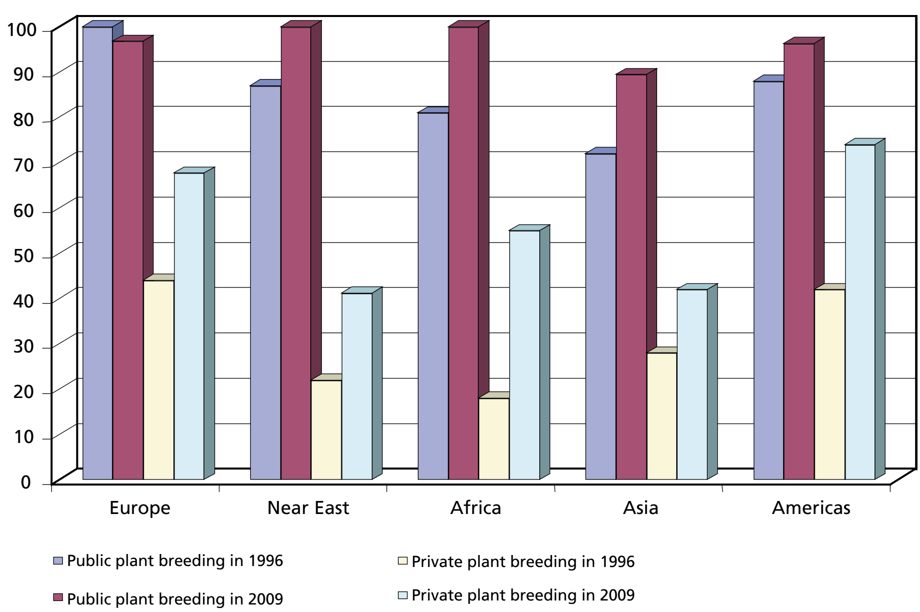
Source: National Information Sharing Mechanism 2008 (available at: www.pgrfa.org/gpa). The figures are based on the response of 404 plant breeders from 49 developing countries to a question on the current trend within the stakeholders' organization in terms of capacity to breed specific crops or crop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

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 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.

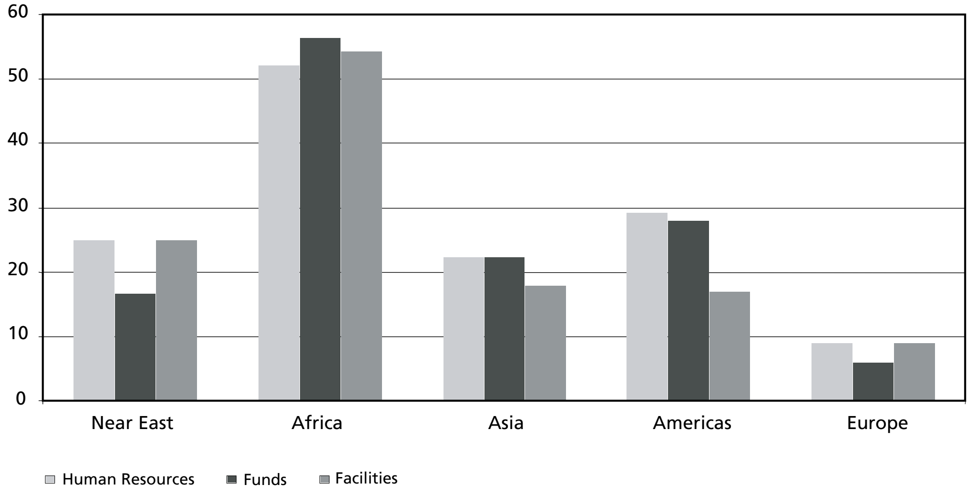
Based on information from the country reports and the GIPB-PBBC database, a comparison has been made between countries that reported in the first SoW report and a similar set of countries in 2009, with respect to public vs. private plant breeding programmes. Overall there has been an increase in the 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, many country reports indicate 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

FIGURE 4.3
Percentage of countries that reported the existence of public and private breeding programmes in the first and second SoW reports



Source: 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 (available at: http://km.fao.org/gipb/pbbc/).

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



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.

and currency devaluation. Resources for field trials and other essential activities are often limiting.[11] In the United States of America, 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]

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.

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 the 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 CWR '… 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 sections 1.2.2 and 3.4.3).

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 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 Marker Assisted Selection (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 for a restricted number of traits in major crops 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 the United States of America 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 reports and information from the FAOSTAT programme,[20] investment in crop improvement seems to largely mirror a 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, and attention to under-utilized crops (see section 4.9.2). In the Americas region, for example, 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 biofuel, as do an increasing number of other countries, including several in Asia. However, in most cases attention is focused on the genetic improvement of existing major crops for biofuel use rather than on new biofuel crops such as switch grass or jatropha.

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, 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, the expansion of production onto more marginal land and climate change. 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 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.

Special attention may be paid to plant breeding in the event of high profile catastrophes such as severe and widespread pests and diseases. This was the case, for example, with the epidemic of brown-streak virus in cassava in Eastern and Southern Africa, and wheat stem rust race Ug99 that led to the creation of The Borlaug Global Rust Initiative (BGRI).[21]

4.6 BREEDING APPROACHES FOR USE OF PGRFA

Plant breeders have at their disposal a wide range of breeding approaches, tools and methods for crop improvement. While the first SoW report makes reference to many of them, this report will only discuss pre-breeding and base broadening, and participatory plant breeding (highlighted in Article 6 of the ITPGRFA), in which significant developments 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 reported using both conventional and molecular marker techniques to exploit 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'. Brazil presented several examples of the use of wild species to expand the genetic base of different crop species. Box 4.2, for example, shows the case of passion fruit (*Passiflora* spp.).

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

Region	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

Source: National Information Sharing Mechanism 2008 (available at: 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 main crops grown.

Pre-breeding occupies a unique and often crucial step between genetic resources conserved in collections and their use by 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 programmes participate strongly. Many of the problems associated with increasing pre-breeding activities are similar to those relating 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.

4.6.2 Farmers' participation and farmer breeding

Participatory Plant Breeding (PPB) is the process by which farmers participate with trained, professional 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 and even hybridization.

Based on country reports, farmer participation in plant breeding activities has increased over the past decade in all regions, in line with 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, reported that for certain crops, participatory breeding approaches are the most suitable way to develop varieties adapted to farmers' needs. Several of them rely almost exclusively on participatory methods to develop improved varieties. Currently there are national and international organizations that devote significant resources to promoting and supporting participatory breeding programmes, for example, Local Initiatives for Biodiversity, Research and Development (LI-BIRD) in Nepal and the Working Group on

TABLE 4.5
Examples of country reports that mention 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
Ecuador	Various – through farmer schools and local agricultural research committees
Guatemala	Maize
India	Maize, rice and chickpea
Jamaica	Pepper, coconut and pumpkin
Jordan	Barley, wheat and lentil
Lao PDR	Rice
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
Philippines	Maize, vegetables and root crops
Portugal	Maize
Senegal	Rice
Thailand	Rice and sesame
Uganda	Beans
Venezuela	Local under-utilized crops

PPB established in 1996 under the framework of the CGIAR System-wide Program on Participatory Research and Gender Analysis (PRGA).

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 stated: '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 reports of many countries in Asia,[22] Africa[23] and Europe.[24]

In spite of the overall increase in PPB, farmer involvement 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'.

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 they comply 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 and threatened by genetic erosion.[26]

While some progress has been achieved in the integration of PPB in national breeding strategies, this remains an area that still requires attention. Although there are exceptions (in Netherlands for example and by some International Centres including CIAT and ICARDA) opportunities for building PPB capacity among farmers and plant breeders are often lacking.

4.7 CONSTRAINTS TO IMPROVED USE OF PGRFA

There was wide agreement among all stakeholders surveyed, regarding the major constraints to a greater and more effective use of PGRFA. 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 GIPB-

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 that experienced staff are retained and remain productive. 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 operating. Public investment is particularly needed for improving crops that do not promise substantial short-term economic returns such as minor and under-utilized crops.[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 (see Chapter 5). 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 Facilities

To a large extent, national programmes view the three major constraints, human resources, funds and facilities, to be at similar levels of importance, e.g. all are very high (Africa) or all are relatively low (Europe). The principal exception to this generalization is the case of facilities in the Americas, seen as considerably less constraining than either human resources or funds. The details on what type of facilities are most constraining varies by region, but generally field and laboratory facilities are both inadequate, and this is especially true in Africa.

4.7.4 Cooperation and linkages

Several country reports expressed concern at the lack of fully effective linkages between basic researchers, 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 Philippines, reported instances of 'close collaboration between breeders and genebank managers…' and cited coconut, sweet potato, yam and taro as examples.

Oman, Saint Vincent and the Grenadines and Trinidad and Tobago all commented specifically on 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.

4.7.5 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 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 many countries do not yet have PGRFA information in national electronic databases, others, such as many of the European countries, have contributed information to regional electronic databases such as EURISCO. Other large databases that contain comprehensive information and that are publicly accessible 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, Czech Republic and Spain reported considerable progress in making information available on line. Netherlands described a further step beyond evaluation data being accessible on line: an on line knowledge bank for educational purposes. The Caucasus and the Central Asia countries created a regional database in 2007 with the aim of strengthening documentation and thereby enhancing use.[31]

Bioinformatics, not discussed at all in the first SoW report, was briefly referred to in several country reports as a relatively new subject. 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 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. Seed also has a cultural value in many societies and is the subject of a wealth of traditional knowledge.

There is a large diversity of means by which farmers obtain seeds. Some authors 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, a given farmer will generally resort to either or both of these approaches for different crops or in different seasons, and they generally do not make a big distinction between the two. Several countries in Africa, including Benin, Madagascar and Mali reported that the farmer seed sector is dominant nationally, although there is crop specificity; 100% of Mali's cottonseed, for example, 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 under-utilized 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, worth $30 billion in 1996 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 and the private sector has taken 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. The Afghanistan, Ethiopia, Jordan, Palestine, Tunisia and Yemen country reports, for example, all 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 investing in areas that are of relatively little commercial interest such as pre-breeding, developing varieties for resource poor farmers and focusing on 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 Netherlands, but there are difficulties in adapting current conventional seed legislation to meet the needs and concerns of this sector.

There is also an expanding market for old, 'heritage' varieties. While the United States of America allows marketing of local varieties without restriction, the EU has a strict seed regulatory framework, although it is currently developing mechanisms that would to permit the legal marketing of seed of 'conservation varieties' of vegetables that would not meet normal uniformity requirements (see section 5.4.2). 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 France, it is possible to market seeds of old vegetable varieties for home gardening and in Hungary the production of seed of old varieties and landraces is considered a priority. Jamaica and Ghana both 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] In the latter year, a total of 114.3 million hectares was planted with GM-crops, mainly soybean, maize, cotton and oilseed rape. While the rate of increase in the area under GM-crops is slowing in developed countries, it is continuing to rise steadily in the developing world. However, 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 still limited – mainly to Argentina, Brazil, Canada, China, India, South Africa and United States of America. 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, more recently, 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 and there are even cases in which seed regulations have outlawed '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. Such harmonization started at the end of the 60s in Europe and at the beginning of this century in some African countries. Furthermore, PBR legislation has played an important role in making new varieties more accessible to farmers in many UPOV member countries.

Biosafety regulatory systems have been developed in order to manage any potentially negative effects that might arise from the exchange and use of GM-crops. The Cartagena Protocol on Biosafety 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. (see section 5.4.5).

Emergency seed aid is an area that has received increased attention in recent years. Following natural disasters and civil conflicts, in order to quickly restart crop production, local and international agencies have often relied on direct distribution of seed to farmers. Such seed has often originated outside the loal area or even the country concerned. 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 by farmers resulted more from the lack of sufficient quantities of basic, commercial and registered seed than the availability and cost of the seed itself or inadequate distribution systems.

4.9 EMERGING CHALLENGES AND OPPORTUNITIES

Since 1996, several of the issues discussed in the first SoW report have become more significant and new ones have emerged. Among these: globalization of economies has continued to move forward (albeit sometimes unevenly), food and energy prices have risen, organic foods have become more popular and economically attractive, and the cultivation of GM-crops has spread widely, while also sometimes causing debate. Several of the emerging issues are intertwined with the wide fluctuations in food and energy prices that have impacted both producers and consumers of agricultural products over recent years. The following sections discuss five such issues. These are: sustainable agriculture and ecosystem services, new and under-utilized crops, biofuel crops, health and dietary diversity and climate change.

4.9.1 Use of PGRFA for sustainable agriculture and ecosystem services[1]

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 action taken to encourage agricultural tourism through, for example, 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. In addition, several country reports[35] indicated a growing interest in organic agriculture systems using crop varieties bred to perform well under low-input

[1] See section 8.2.2.

conditions. 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] can also contribute to sustainable agriculture by helping reduce requirements for agrochemicals. However, their use is often limited by policies and legislation in producing and/or importing countries. The potential negative impact of the cultivation of genetically engineered crops on PGRFA, especially in their centers of origin and diversity has sometimes 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" and the Global Horticulture Initiative 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 has 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 Netherlands reported on its niche markets for under-utilized 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 Pacific 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 Philippines reported an interest in biofuels and Zambia mentioned *Jatropha curcas*, the oil of which is a diesel substitute. This and several more traditional crops that can be used for biofuel, 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 the 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 net global CO_2 emissions.

Biofuel crops for use in power stations were mentioned by Germany, and several European countries[40] and the United States of America[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 but 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 on 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:

- Golden rice, which contains high levels of beta-carotene, the precursor of Vitamin A, through an introduced biosynthetic pathway;
- 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;
- Numerous on-going research projects on iron, zinc, provitamin A, carotenoids, selenium and iodine.

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

- 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-carotene, iron and zinc;[46]
- The Grand Challenges in Global Health Initiative, targeting banana, cassava, sorghum and rice, mostly through genetic modification;[47]

➢ The Biodiversity and Nutrition Initiative led by the CBD, FAO and Bioversity International.

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]

All of the climate models of the IPPC predict that conditions for agriculture in the future will be dramatically different from those that prevail today.[50] Of all economic activities, agriculture will be among those in greatest need to adapt. Many 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 CWR. These changes are expected to result in a growing demand for germplasm that is adapted to the new conditions, more effective seed systems and international policie s and regulations that will facilitate even greater access to PGRFA.

The country reports made relatively few references to the predicted impact of climate change. However, together with rapidly growing demand for greater production, such change is likely to result in increased pressure to cultivate more marginal land. Africa is the continent that is most vulnerable to climate change and it has been suggested that maize will probably be eliminated from southern Africa by 2050. It is also predicted that groundnut, millet and rapeseed productivity will also drop in South Asia.[51] Small islands, that often have high levels of threatened endemic species, are also under particular threat as a result of the expected rise in sea level.

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 at least 10 to 20 years hence, requiring that prediction methods be further developed so as to be as reliable as possible. Certain currently under-utilized crops are likely to assume greater importance as some of today's 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.

In order to meet the challenges posed by climate change, it will be vital that effective plant breeding programmes are in place, with adequate human and financial resources, in all key agroecologies. It is predicted that climate change will have a significant impact within the relatively near future, and given the long time required for a typical crop breeding cycle, it is essential that all necessary action be taken immediately to strengthen and accelerate breeding efforts.

4.10 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. A good example of this dimension was the well documented case of potato in developing countries that was highlighted as part of the celebration of the 'International Year of the Potato'.[52]

4.11 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 under-utilized crops and to the use of CWR;
- The number of accessions characterized and evaluated, and the number of countries where characterization and evaluation are carried out have increased in all regions but not in all individual countries. An increasing number of countries use molecular markers to characterize their germplasm;
- Progress has been made in genetic enhancement and base broadening with several countries now 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 those 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 under-utilized crops, biofuel crops, health and dietary diversity, and climate change;
- There has been a substantial increase in awareness over the past decade of the extent and nature of the threats posed by climate change, and of the importance and potential of PGFRA in helping agriculture to remain productive under the new conditions through their underpinning of efforts to breed new, adapted crop varieties;
- The area sown to transgenic crops has increased substantially since 1996 and the seed market has grown in value in step with this. 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 development of improved varieties, and the marketing of high quality seeds of major crops 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 remains 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, East Africa, 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.

4.12 GAPS AND NEEDS

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

- There is an urgent need to increase plant breeding capacity worldwide in order to be able to adapt agriculture to meet the rapidly expanding demand for more and different food, as well as non-food products, under substantially different climatic conditions from those prevailing today. The training of more breeders, technicians and field workers, and the provision of better facilities and adequate funds are all essential;
- The need for greater awareness among policy makers, donors and the general public of the value of PGRFA, and the importance of crop improvement, in meeting future global challenges;

- There is a need for countries to adopt appropriate and effective strategies, policies, 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;
- 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 use of participatory breeding, many countries need to reconsider their policies and legislation, including developing appropriate intellectual property protection and seed certification procedures for varieties bred through PPB. Greater attention is also needed to capacity building and to ensuring PPB is integrated in 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), 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), was set up by the University of Ghana to improve the crops that feed the people of West Africa;
- A scheme has been launched in the United States of America to halt the decline of public investment in plant breeding. It is coordinated through a taskforce of the Plant Breeding Coordinating Committee;
- The Generation Challenge Programme (GCP) 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 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 of 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. See, for example, the country reports of Egypt, Indonesia and Romania.
[2] For example Brazil, China, Malaysia and Russian Federation.
[3] For example Chile, Lebanon, Pakistan and Thailand.
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CHAPTER 5

The state of national programmes, training needs, and legislation

5.1 INTRODUCTION

National programmes for the conservation and sustainable use of PGRFA 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 nature 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 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. In this case, 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 their type of national programme 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 for the second report 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 101 countries[1] that contributed information for both the first and second SoW reports, 53% reported having a national programmes in 1996, whereas 71% 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 for which information was provided for the second SoW report either through a country report, an NISM, or participation in a regional workshop,[2] 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, section 4.7.3), the weak links between the PGRFA conservation and use sectors are 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 is a more effective integration of the efforts of the public and private sectors (see Chapters 1 and 4). 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.

Country reports from many regions mentioned NISM on the Implementation of the GPA as a valuable tool for establishing and improving national programmes.[3] Participating countries recognized their helpful role in facilitating the management of information 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, 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 determining and sharing responsibilities. They are also important in the regional and international context in helping to raise awareness of the value of PGRFA and the actions being undertaken by other countries to conserve and use it.

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 categories 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, help has sometimes come from international and regional organizations, bilateral agencies, and private foundations. In general, funding support from such agencies for the conservation and use of PGRFA in developing countries appears to have increased since the first SoW report was published.

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 GCDT and the opening of the SGSV have served to raise awareness of the importance 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.

5.2.5.1 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, multilocation 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, United States of America, Australia, and other industrialized countries, the private sector now accounts for a large proportion of the total breeding effort (see section 4.4) 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.

5.2.5.2 NGOs

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. Germany, Netherlands, and Switzerland reported the effective involvement of NGOs. 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.

5.2.5.3 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 of 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 priorities listed in the GPA. Expanding and improving education and training is Priority Activity Area 19 in the plan and capacity building is addressed by the entire fourth section. Strengthened staff competence is needed in all sectors: scientists and technicians, development workers, NGOs, and farmers, and special efforts are needed to educate research managers and policy makers. In many countries biological sciences curricula at all educational levels need to be developed or updated to include conservation biology, especially with respect to agrobiodiversity.

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 in areas related to PGRFA. 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 section 4.6.2) 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 as a result of the 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 limited. Universities in Benin, Ghana, Kenya, and Madagascar all reported that courses on genetic resources have been included in university curricula at both the undergraduate and postgraduate levels. In Benin and Côte d'Ivoire, postgraduate 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- 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 postgraduate 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 postgraduate 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 on 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: 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 NIAS/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, LI-BIRD 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 training documents and other materials for use in education and training programmes.

Since 1996, NBPGR and IARI in New Delhi have offered joint M.Sc. and Ph.D. degree programmes in the conservation and management of genetic resources. Formal degree programmes were also 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 of the importance of conserving biodiversity in general and agrobiodiversity in particular. the Syrian Arab Republic, 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 the Syrian Arab Republic, 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. Appendix 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 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 section 6.4.1 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 section 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 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 seed control and certification and variety release procedures. Since the first SoW report was published, three main trends have occurred: the emergence of voluntary arrangements regarding seed certification and variety release; the growing use of accreditation principles within official national rules and standards; and the regional harmonization of seed laws (see section 4.8).

Recent years have seen a significant development of the seed trade by the public and, especially, private sectors, largely in parallel with the more traditional seed exchange arrangements of local agricultural communities. This has led governments to set up seed regulations for the protection of seed users (farmers, consumers, and agri-food industries) that cover such areas as catalogues of plant varieties, marketing authorization, and seed-quality control.

In some countries including Australia, Canada, and New Zealand as well as some Latin American, African, and Asian countries, the growth of the private seed sector has led governments to review their seed laws, resulting in many cases in a shift away from compulsory rules on seed certification and variety release towards more voluntary arrangements. The largely self-regulated nature of variety release and seed certification in the United States of America allows for the marketing of seeds of local varieties. In India, changes have been made in the other direction – from voluntary arrangements 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 within the national or regional seed rules and standards of a number of industrialised countries and ones with emerging economies. 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. Taking into account the evolution of seed regulations, the ISF has regularly updated 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 where seed certification and seed quality standards[11] were adopted in the late 1960s and a common variety catalogue established in 1970. In 2008, the concept of 'conservation varieties' was introduced. These are varieties that, although they must meet quality standards, have neither to adhere to strict uniformity and stability rules nor have any proven value for cultivation and use.[12] However, such 'conservation varieties' are limited to old and locally used varieties that are threatened by genetic erosion.

In the countries of Southern Africa, the harmonisation of seed laws with the assistance of FAO resulted in the adoption in the early 2000s of 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 SADC regional list. Harmonisation efforts are also underway in Western Africa with the development of a joint variety list by members of the ECOWAS 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 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 aim to protect the seed label and are reserved for controlled seeds, labelled 'Government-certified seeds', 'Government-tested seeds', or the like. The Moroccan seed law restricts the use of the word 'seed' to controlled seed 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 PBR and patents. The following sections give an overview of the state of play at the national level in both of these areas. Other forms of IPR can also play a role, for example trade secrets for protecting inbred lines for producing hybrid varieties, geographical indications for protecting products that have a specific geographical origin and possess qualities, reputation, or characteristics that are essentially attributable to that origin, and copyright for protecting databases and other information sources. However, these are not considered further in this report.

5.4.3.1 Plant breeders' rights

According to the UPOV, PBR allow breeders the exclusive right to sell seed or propagating material of their new varieties over a given number of years, although these varieties can still be used without restriction for research and further breeding ('breeders' exemption'). The number of countries that provide legal protection to plant varieties through PBR has increased substantially over the past 10 years. While most western European countries, the United States of America, Canada, Australia, and New Zealand already had PBR systems in place prior to the publication of the first SoW report, most countries in Africa, Asia, Latin America and the Caribbean, Eastern Europe, and Near East that have enacted PBR legislation have done so in the last decade.

The move to enact PBR legislation largely results from the TRIPS Agreement of the WTO 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). Although there is no mention of UPOV in the TRIPS Agreement, the UPOV *sui generis* models are widely considered to meet the requirements of TRIPS, and as a result the number of countries that have joined UPOV almost doubled between 1998 and 2007, reaching 67 in May 2009.

The increasing membership of UPOV is also a consequence of a number of free-trade agreements that have been concluded that extend standards of IPR protection beyond the TRIPS requirements, for instance by making explicit reference to UPOV.

In Africa, Burkina Faso, Cameroon, Kenya, and South Africa have all implemented PBR legislation, while four other countries have developed a national *sui generis* plant variety protection system.[13] Six other countries[14] are in the process of developing or approving such regulations. At the regional level, the African Intellectual Property Organization (Organisation Africaine de la Propriété Intellectuelle, OAPI) revised the Bangui Agreement in 1999 that governs the common intellectual property regime of its 16 member states.[15] The new Agreement establishes, in its Annex X, a uniform PVP system that conforms with UPOV and foresees that the OAPI member states will join UPOV by depositing an instrument of accession to the 1991 Act. In addition, the African Regional Industrial Property Organization (ARIPO) is currently drafting a regional PVP system.

In Asia and the Pacific, 7 countries[16] have implemented PBR and 8 other countries have developed a national *sui generis* plant variety protection system,[17] 13 of these having done so in the last decade. Philippines and Singapore have initiated the procedure for accession to UPOV and Nepal is currently drafting a bill on PVP.

In the Americas, 14[18] of the 34 countries in Latin America and the Caribbean have PBR legislation in place and seven others[19] have developed national *sui generis* plant variety protection systems. Guatemala, Saint Vincent and the Grenadines have developed draft legislation. In all countries except Argentina, Chile, Colombia, Cuba, Paraguay, and Uruguay, the legislation has been adopted since the publication of the first SoW report. At the sub-regional level, the five Member States of the Andean Community adopted Decision 345 on Common Provisions on the Protection of the Rights of Breeders of New Plant Varieties that was modelled according to the UPOV Convention of 1991 (see section 6.4).

All European countries have put in place or drafted national legislation on PBR or PVP except Greece, Lichtenstein, Luxembourg, Monaco 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. At the European Union level, the Council Regulation No. 2100/94 on Community plant variety rights provides for the protection of PBR throughout the territory of the 27 EU Member States in addition to national systems already in place.

Twenty-one of the 30 countries in the Near East region have adopted either PBR or a national *sui generis* plant variety protection system,[20] 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.

5.4.3.2 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. While parties are allowed to exclude from patentability 'plants and animals other than micro-organisms, and essentially biological processes for the production of plants and animals other than non-biological and microbiological processes', they must provide 'by patents or by an effective *sui generis* system or by any combination thereof', for the protection of plant varieties. Part of the controversy arises from the fact that 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 trait within a whole species. Furthermore, while patents applied to plant varieties generally include a limited research exemption, unlike the situation with PBR and UPOV, they generally do not include either a breeder's exemption or a farmer's privilege. There are, however, exceptions to this, for example in France, Germany, and Switzerland.

Today relatively few countries allow patent protection for new crop varieties. However, the patent system is widely used in the United States of America, 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 requirement for patentability is interpreted in such a way that new varieties that exceptionally 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, however it excludes plant varieties from patentability. 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.

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.

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. The Article recognizes that the responsibility for realizing farmers' rights, as they relate to PGRFA, rests with national governments. 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. While all Contracting Parties of the ITPGRFA are legally bound by it, they are free to determine how they will implement the farmers' rights provisions at the national level.

The state of national implementation of farmers' rights is the focus of a recent study by the Fridtjof Nansen Institute in Norway.[21] 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.

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 farmers' rights have generally done so within their plant variety protection legislation. At least ten countries have reported that they have adopted regulations covering one or more aspects of farmers' rights and several others are currently drafting legislation in this area. Many other countries do not regard it necessary for them to enact specific legislation of farmers' rights but meet their obligations under the ITPGRFA through existing mechanisms such as PBR or national participatory decision systems.

Even before the concept of farmers' rights was formally adopted in the ITPGRFA, a number of countries including Bangladesh, India, and Thailand had already implemented legislation that protected farmers' rights in terms of the right to save, use, exchange, and sell farm-saved seeds, participate in making decisions and, in the case of India, introduced a 'Gene Fund' financed by all users, including farmers, to support farmers who maintain genetic resources (see Box 5.2).

In Africa, Ethiopia, Ghana, Malawi, and Namibia are currently developing specific regulations on farmers' rights and in fact Ethiopia has already implemented some aspects of farmers' rights in its Access to Genetic Resources and Community knowledge and Community Rights Proclamation No. 482/2006.

In the Americas, Costa Rica has addressed the issue of farmers' rights by 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. Other countries have addressed some aspects of farmers' rights, such as Brazil in its plant variety protection act and seed law as well as Cuba and Paraguay.

In Asia and the Pacific, in addition to Bangladesh, India, and Thailand, 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 only need to be distinct and identifiable. The Act also allows 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 specific legislation on farmers' rights[22] although the Islamic Republic of Iran and Turkey are currently developing specific laws in this area. However, the Islamic Republic of Iran has already implemented some aspects of farmers' rights in broader legislation. Pakistan has drafted legislation on access to biological resources and community rights that addresses some aspects of farmers' rights.

In most industrialized countries, where farmers' organizations tend to be well connected to policy processes, the issue of farmers' rights has not taken on as much importance and the debate on the use of farm-saved seed is generally held in the framework of IPR and seed legislation. In Europe, while only Italy has adopted specific regulations on farmers' rights, many other countries, for example Austria and Estonia, consider that they have adequately addressed, or are in the process of addressing, aspects of farmers' rights in other legislation and regulations as appropriate. However, several countries in the region are now considering how they might best support the realization 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.'[23] Concerns over biosafety have grown substantially over the last decade, in parallel with the expanding use of genetically modified organisms (GMOs) 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 GMOs 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[24] in 2000 marked a milestone in cooperation on the safe transfer, handling, and use of GMOs. The Cartagena Protocol entered into force in 2001, and as of August 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 United States of America 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, the application of the 'precautionary principle' can block use of a GMO until evidence is presented that the transgenic organism is safe. This has limited the number of approvals that have been granted for the commercial use of GMOs, and even fewer approvals for their deliberate release into the environment. At the EU level, *Directive 2001/18/EC on the release of GMOs* was adopted in 2001. At the national level, all 27 EU Member States have enacted biosafety or biotechnology-related laws and among non-EU European countries, eight[25] have done so as well. Albania, Armenia, Bosnia and Herzegovina, 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[26] have adopted formal biosafety measures while 33 other African countries[27] 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 Caribbean nations, only Belize and Cuba have enacted biosafety laws, although in 12 other countries,[28] legislation is being formulated.

In Asia and the Pacific, legislation or guidelines on biosafety are in place in eleven countries[29] and draft regulations are under development in 15,[30] while in the Near East, Cyprus, Egypt, Israel, Kazakhstan, Malta, Pakistan, Syrian Arab Republic, and Tajikistan have adopted biosafety legislation and it is under development in 12 other countries.[31]

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 101 countries that provided information for both the first and second SoW reports, 53% had a national programme in 1996 whereas 71% 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 IPPC;
- There have been three main trends in national seed legislation and policy over the past decade: the emergence of voluntary arrangements 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 August 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 and need to be strengthened;
- 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 country reports indicated that they had no 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;
- Greater efforts are needed to include the concepts of conservation biology, especially with respect to agrobiodiversity, in biological sciences curricula at all levels;
- 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 policy makers, donors, and the private sector as to the actual and potential value of PGRFA;
- Greater attention is needed in many countries to the development of appropriate,

non-conflicting and complementary national policies and legislation relating to the conservation, exchange, and use of PGRFA, including such areas as phytosanitary regulations, intellectual property protection, farmers' rights, and biosafety, and taking into account the needs and concerns of all stakeholders.

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

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] Comprising 93 countries that presented complete country reports as a contribution for the preparation of the Second State of the World's Plant Genetic Resources and eight countries that provided information during the Near East and North Africa regional consultation, 2008.

[2] The Near East and North Africa, and the Latin American and the Caribbean regional consultations allowed information from countries that did not present country reports, to be gathered by responding to the short questionnaire, or through a National Information Sharing Mechanism.

[3] Available at: http://www.pgrfa.org/

[4] For example in Australia, Brazil, China, India, Philippines, Thailand and United States of America.

[5] For example Cyprus, Dominican Republic, Ethiopia, Germany, Jamaica, Jordan, United Republic of Tanzania and Thailand.

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

[7] CIP-UPWARD. 2003. Conservation and sustainable use of agricultural biodiversity. A sourcebook. International Potato Center (CIP), Lima. 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 (IFPRI), Washington DC and IPGRI. Rome.

[9] Country Reports: India, Nepal and Uganda.

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

[11] 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.

[12] Commission Directive 2008/62/EC of 20 June 2008 on conservation varieties.

[13] Côte d'Ivoire, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.

[14] Ethiopia, Ghana, Malawi, Mauritius, Namibia and Uganda.

[15] Benin, Burkina Faso, Cameroun, Central African Republic, Chad, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Guinea, Guinea Bissau, Mali, Mauritania, Niger, Senegal and Togo.

[16] Australia, China, Japan, Republic of Korea, Malaysia, New Zealand and Viet Nam.

[17] Bangladesh, Bhutan, India, Indonesia, Philippines, Singapore, Thailand and Sri Lanka.

[18] Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago and Uruguay.

[19] Barbados, Belize, Cuba, Dominica, El Salvador and Venezuela.

[20] 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 the Near East and North Africa Regional Analysis of Plant Genetic Resources for Food and Agriculture, 2008.

[21] **Andersen, R. and Tone W.**, 2008. The Farmers' Rights Project – Background Study 7: Success Stories from the Realization of Farmers' Rights Related to Plant Genetic Resources for Food and Agriculture. FNI Report 4/2008. 72 pp. Available at: http://www.fni.no/doc&pdf/FNI-R0408.pdf

[22] Near East and North Africa Regional Analysis of Plant Genetic Resources for Food and Agriculture, 2008.

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

[24] Available at: http://www.cbd.int/biosafety/

[25] Belarus, Former Republic of Macedonia, Republic of Moldova, Norway, Russian Federation, Serbia, Switzerland and Ukraine.

[26] For example Benin, Burkina Faso, Cameroon, Kenya, Malawi, Mauritius, Namibia, South Africa, United Republic of Tanzania, Uganda, Zambia and Zimbabwe.

[27] Botswana, Burundi, Cape Verde, Central African Republic, Chad, Comoros, Congo, Democratic Republic 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.

[28] Country reports: Antigua and Barbuda, Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Guyana, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines and Suriname.

[29] Australia, China, Japan, India, Indonesia, Republic of Korea, Malaysia, Nepal, New Zealand, Philippines and Viet Nam.

[30] 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.

[31] Algeria, Iran, Jordan, Kyrgyzstan, Lebanon, Libyan Arab Jamahiriya, Morocco, Oman, Qatar, Tunisia, 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 ITPGRFA 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.

Section 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 GCDT.

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	IICA
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

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 SSA: 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] 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 CORAF/WECARD.[4] Various meetings have been held including in Ibadan, Nigeria in 2004 and 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 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 United States of America are focusing collectively through NORGEN on information exchange, training, collecting bean wild relatives in Mexico 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 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.
- The Plant Genetic Resources Network for the Southern Cone (REGENSUR): This network, comprising six countries,[9] 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.

- Mesoamerican Network on Plant Genetic Resources (REMERFI): This network of eight countries[10] 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 Amazonian Network for Plant Genetic Resources (TROPIGEN): Operating under PROCITROPICOS, 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.

- Regional Network for Conservation and Use of Plant Genetic Resources in East Asia (EA-PGR):[13] EA-PGR promotes collaboration among its five member countries[14] 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 Republic of Korea; and (v) establishing a network website.
- The Pacific Agricultural Plant Genetic Resources Network (PAPGREN):[15] Established in 2001, PAPGREN comprises 13 nations[16] 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):[17] 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,[18] 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.
- 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[22] 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 AEGIS,[23] a programme that aims to rationalize collections (see section 7.3.3.2) as well as EURISCO,[24] a globally accessible catalogue, launched in 2003, that contains information on more than 1.1 million accessions.

- The Nordic Genetic Resources Centre (NordGen):[25] NordGen is an institution under the Nordic Council of Ministers.[26] It was established in 2008 through a merger of the Nordic Gene Bank, the Nordic Gene Bank for Farm Animals and the Nordic Council for Forest Reproductive Material.
- 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 the Caucasus Association of Agricultural Research Institutions (CACAARI),[27] which was established in 2004.

- The Central Asian and Caucasian Network on Plant Genetic Resources (CACN-PGR):[28] This network, established in 1999, involves eight countries[29] 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[30] 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)[31] 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)[32] 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 CORAF/WECARD, 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)[33] in 2000 and now operates under FORAGRO. Likewise, the INIBAP Asia-Pacific Network (ASPNET) was renamed the Banana Asia Pacific network (BAPNET)[34] 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)[35] 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),[36] 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 PGRFA 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 (Islamic Republic of 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)[37] 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),[38] the SADC Seed Security Network (SSSN)[39] 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)[40] 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 provides administrative, scientific and technical support to the work of both the Secretariat of the 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 GPA 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 section 7.2.1 and is only mentioned briefly below.

- The Commission on Genetic Resources for Food and Agriculture (CGRFA):[41] 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 CGRFA established two International Technical Working Groups, one on plant genetic resources and the other on animal genetic resources.

  The CGRFA provided the forum for the successful negotiation of the ITPGRFA, a legally-binding international agreement that came into force in June 2004 (see section 7.2.1). The CGRFA acted as the Interim Committee for the ITPGRFA until 2006, when its own Governing Body was established. The CGRFA also developed the first GPA, and is responsible for monitoring its implementation. At its eleventh regular session in June 2007, the CGRFA 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):[42] 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 sections 4.4 and 7.3.2.
- Agreement with the Convention on Biological Diversity: One area in which significant progress has been made is in the strengthening of the relationship with the CBD. 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[43]

The first SoW report described the then 16 - now 15[44] - 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[45] with the aim of achieving a more focused research agenda, greater coherence among the Centres and increased collaboration with a wider range of partners. However, the management of the genetic resources collections is expected to remain a high priority for the System as are 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 section 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 GCP and Harvest Plus (see section 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".[46]

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),[47] 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)[48] 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[49] and ILRI[50] 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[51] 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[52] provides leadership for a number of regional networks on potato and/or, sweet potato as well as the Potato Gene Engineering Network (PotatoGENE);
- ICARDA[53] 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[54] 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[55] has important collections of many tropical crops and works in close collaboration with national programmes, networks and other institutions throughout Sub-Saharan Africa;
- IRRI[56] convenes the International Network for the Genetic Evaluation of Rice (INGER)[57] and the Council for Partnerships on Rice Research in Asia (CORRA);[58] 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 institutions

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 major new safety back-up facility for the storage of duplicate samples of accessions held in seed collections (see section 3.5). Just five examples of regional and international institutions are given below: two are new since the first SoW report was published, two are important agricultural research institutions that have gone through significant changes over recent years and one, the Convention on Biological Diversity, has significantly expanded its work related to PGRFA.

- The World Vegetable Center (formerly AVRDC):[59] 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.
- Center for Tropical Agricultural Research and Education (CATIE):[60] CATIE is an intergovernmental regional research and higher education centre located in Costa Rica. While it seeks primarily to serve its member countries,[61] 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.).
- Convention on Biological Diversity (CBD):[62] in November 1996, the third Conference of the Parties to the CBD adopted decision III/11: 'Conservation and sustainable use of agricultural biological diversity', which, *inter alia*, established a multi-year programme of activities on agricultural biological diversity with the following goals:
  - Promote the positive effects and mitigate the negative impacts of agricultural practices on biological diversity in agro-ecosystems and their interface with other ecosystems
  - Promote the conservation and sustainable use of genetic resources of actual or potential value for food and agriculture
  - Promote the fair and equitable sharing of benefits arising out of the utilization of genetic resources

PGRFA are also important in a number of the cross-cutting programmes of work of the CBD including the ecosystem approach, climate change and biodiversity, invasive alien species, the global strategy for plant conservation, and access and benefit sharing (see Chapter 7). In addition the Cartagena Protocol on Biosafety, which came into force in 2003, has major implications for the conservation, management and use of PGRFA and in particular the development and dissemination of genetically modified crop varieties.

- Crops for the Future:[63] 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):[64] 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 ISF[65] and CropLife International;[66] farmers organizations such as the International Federation of Agricultural Producers;[67] international academic institutions such as the Third World Academy of Science (TWAS);[68] and environmental networks such as the IUCN.[69] 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.[70] 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, Republic of Korea and United States of America.

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 section 3.9), and this has been reflected in the growth in membership of the umbrella organization, BGCI, 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

Arguably the most important international events associated with PGRFA since the publication of the first SoW report were the adoption in 2001 and entry into force in 2004 of the ITPGRFA.[71] As of September 2009, the ITPGRFA had been ratified by 120 countries and the EU. Article 1.1 of the ITPGRFA states its objectives as, "the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security."

The ITPGRFA covers all PGRFA and promotes, *inter alia:* conservation, exploration, collection, characterization, evaluation and sustainable use. It promotes action at the national level as well as international cooperation and technical assistance. One article is devoted to Farmers' Rights (see sections 5.4.4 and 7.4) and a centerpiece of the ITPGRFA is the creation of a multilateral system for access and benefit sharing that covers the 35 food crops and 29 forage genera listed in Annex 1 of the ITPGRFA. Developments with respect to access and benefit sharing are described in detail in Chapter 7 of this report.

The ITPGRFA also promotes the implementation of the GPA and recognizes several other supporting components including the *ex situ* collections held by the IARCs, international plant genetic resources networks and the global information system on PGRFA. The Contracting Parties undertake to implement a funding strategy for the implementation of the ITPGRFA with the objective of enhancing the availability, transparency, efficiency and effectiveness of the provision of financial resources to implement activities under the ITPGRFA.

In addition to the ITPGRFA, a trend towards stronger regional cooperation in matters relating to PGRFA is also 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,[72] access and benefit-sharing, farmers' rights,[73] the conservation of natural resources,[74] and safety in the application of biotechnology.[75]

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.[76] In the Nordic countries, the Nordic Council of

Ministers adopted a Ministerial Declaration on Access and Rights to Genetic Resources in 2003.

6.4.1 Regional and international collaboration regarding phytosanitary issues

In 1997, a new text of the IPPC[77] 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).[78] 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 GCDT. 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):[79] 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 GCDT. With its own Executive Board, acting under the overall guidance of the Governing Body of ITPGRFA and the advice of a Donor Council, the GCDT 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 GCDT has also raised funds to support the upgrading of collections and facilities, building human capacity, strengthening information systems, evaluating collections and targeted 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 GCDT.

In spite of the success of the GCDT 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 CWR, 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 FONTAGRO,[80] 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 United States of America, 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. Most of the national development assistance agencies of the OECD countries, for example, are active in this area. Some countries also have specialized 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), the Swedish Agency for Research Cooperation (SAREC – now incorporated in the Swedish International Development Cooperation Agency, Sida) and the International Foundation for Science (IFS) of Sweden.

6.6 CHANGES SINCE THE FIRST SOW REPORT WAS PUBLISHED

It is evident from the information presented in this Chapter that in general regional and international collaboration have advanced considerably since the first SoW report was published. While some networks are still under-resourced, a number of new institutions and partnerships have been established and old mechanisms strengthened. The ITPGRFA's Multilateral System provides a mechanism that makes it easier for countries to share the burden of conservation, leading over time to a greater rationalization of collections (including the elimination of inadvertent duplication) and safety backup duplication, and making it easier for countries to work together to conserve and use a wider range of genetic diversity. Key changes that have taken place include:

- The entry into force of the ITPGRFA in 2004 marks what is probably the most significant development relating to plant genetic resources since the publication of the first SoW report. The ITPGRFA is a legally binding international agreement that promotes the conservation and sustainable use of PGRFA and the fair and equitable sharing of the benefits arising out of their use, in harmony with the CBD.
- 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-PGRN 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, a number of networks have been created on biotechnology, both globally (e.g. the GCP) and in many regions. Other topics have included the on farm management of genetic diversity, and seed production. Three seed networks have been established in Africa alone;

- FAO supports the Secretariats of both the ITPGRFA and the 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 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 Centres 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 ICBA;
- The SGSV, which opened in 2008, represents a major new international 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 GFAR. The Forum 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 to promote the effective implementation of ITPGRFA, and in particular its multilateral system of access and benefit sharing, as well as to develop arrangements for those other crops that are not currently included in the system but that are within the overall scope of the ITPGRFA;
- 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.

[1] Available at: www.fara-africa.org
[2] Available at: www.asareca.org/eapgren/
[3] EAPGREN members are: Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, United Republic of Tanzania and Uganda.
[4] Available at: www.coraf.org/English/English.html
[5] Available at: http://www.spgrc.org/
[6] Available at: www.iica.int/foragro
[7] Available at: webiica.iica.ac.cr/prociandino/red_redarfit.html
[8] REDARFIT members are: Bolivia, Colombia, Ecuador, Peru and Venezuela.
[9] REGENSUR members are: Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay.
[10] REMERFI members are: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama.
[11] TROPIGEN members are: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela.
[12] Available at: www.apaari.org
[13] Available at: http://ea-pgr.net/
[14] EA-PGR members are: China, Democratic People's Republic of Korea, Republic of Korea, Mongolia and Japan.
[15] papgren.blogspot.com/
[16] PAPGREN members are: Cook Islands, Fiji, Federated States of Micronesia, Kiribati, Marshall Islands, New Caledonia, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu.
[17] Available at: www.recsea-pgr.net/
[18] RECSEA-PGR members are: Indonesia, Malaysia, Philippines, Papua New Guinea, Thailand, Singapore and Viet Nam.
[19] Available at: www.bioversityinternational.org/scientific_information/information_sources/networks/sanpgr.html
[20] SANPGR Members: Bangladesh, Bhutan, India, Maldives, Nepal and Sri Lanka.
[21] Available at: www.ecpgr.cgiar.org/
[22] For a list of participating countries see: www.bioversityinternational.org/networks/ecpgr/Contacts/ecpgr_nc.asp
[23] Available at: www.ecpgr.cgiar.org/AEGIS/AEGIS_home.htm
[24] Available at: eurisco.ecpgr.org/
[25] Available at: www.nordgen.org/index.php/en/
[26] NordGen members are: Denmark, Finland, Iceland, Norway and Sweden.
[27] Available at: www.cacaari.org
[28] Available at: www.cac-biodiversity.org/main/main_meetings.htm
[29] CACN-PGR Members: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.
[30] Available at: www.aarinena.org
[31] Available at: www.inbar.int
[32] Available at: www.cacaonet.org
[33] Available at: www.bananas.bioversityinternational.org/content/view/75/105/lang,en/
[34] Available at: bananas.bioversityinternational.org/
[35] Available at: www.clayuca.org
[36] Available at: www.spc.int/TaroGen/
[37] Available at: www.coffeegenome.org/
[38] Availabel at: www.african-seed.org/
[39] Available at: www.sdc.org.za/en/Home/Domains_of_Intervention_and_Projects/Natural_Resources/SADC_Seed_Security_Network_SSSN
[40] Available at: www.cbdcprogram.org
[41] Available at: www.fao.org/ag/cgrfa/
[42] Available at: km.fao.org/gipb/
[43] Available at: www.cgiar.org/
[44] The programmes of ISNAR were taken over by IFPRI in 2004.
[45] Available at: www.cgiar.org/changemanagement/

[46] Available at: www.sgrp.cgiar.org/?q=node/583
[47] Available at: www.warda.org
[48] Available at: www.bioversityinternational.org/
[49] Available at: www.ciat.cgiar.org
[50] Available at: www.ilri.org/
[51] Available at: www.cimmyt.org/
[52] Available at: www.cipotato.org
[53] Available at: www.icarda.org/
[54] Available at: www.icrisat.org/
[55] Available at: www.iita.org
[56] Available at: www.irri.org/
[57] Available at: seeds.irri.org/inger/index.php
[58] Available at: www.irri.org/corra/default.asp
[59] Available at: www.avrdc.org/
[60] Available at: www.catie.ac.cr
[61] CATIE members are: Mexico, Dominican Republic, Guatemala, Honduras, El Salvador, Belize, Nicaragua, Costa Rica, Panama, Venezuela, Colombia, Bolivia and Paraguay.
[62] Available at: www.cbd.int/
[63] Available at: www.cropsforthefuture.org/
[64] Available at: www.biosaline.org/
[65] Available at: www.worldseed.org
[66] Available at: www.croplife.org
[67] Available at: www.ifap.org
[68] Available at: www.twas.ictp.it/
[69] Available at: www.iucn.org
[70] Available at: www.egfar.org/
[71] Available at: www.planttreaty.org
[72] Agreement Revising the Bangui Agreement of 2 March 1977, Annex X, 1999.
[73] African Union Model Law on Rights of Local Communities, Farmers, Breeders and Access, 2001.
[74] African Convention on the Conservation of Nature and Natural Resources (Revised version), 2003.
[75] African Union: African Model Law on Safety in Biotechnology, 2001.
[76] EC Council Regulation No. 2100/94 of 27 July 1994 on Community plant variety rights.
[77] Available at: https://www.ippc.int/IPP/En/default.jsp
[78] Available at: http://www.wto.org/english/tratop_e/sps_e/spsagr_e.htm
[79] Available at: www.croptrust.org
[80] Available at: www.fontagro.org

CHAPTER 7

Access to plant genetic resources, the sharing of benefits arising out of their utilization and the realization of farmers' rights

7.1 INTRODUCTION

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 in all areas of the conservation and use of PGRFA.

7.2.1 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. 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 prior informed consent and mutually agreed terms. 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. These standard terms and conditions are set out in the 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.

7.2.1.1 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 the exchange of information, access to and transfer of technology, capacity building, and the sharing of monetary and other benefits arising from commercialization (see Box 7.1). The benefit-sharing fund that has been established for the purpose of receiving the revenues arising from commercialization 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. As of mid 2009, voluntary contributions to the fund have been made by a number of governments, including a commitment by the Government of Norway to make a voluntary contribution to the benefit-sharing fund equal to 0.1% of the value of all seeds sold in Norway. The ITPGRFA Secretariat's first call for proposals under the Benefit-Sharing Fund closed in January 2009 and the first 11 project grants were awarded before 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 ITPGRFA. 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 section 6.5).

7.2.1.2 Enforcement of the terms and conditions of the SMTA

The SMTA provides a mechanism for overcoming potential difficulties of enforcement by empowering FAO, as the entity chosen by the Governing Body to represent its interests as a third party beneficiary under the SMTA, to initiate action where necessary to resolve disputes.

7.2.2 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. The Bonn Guidelines were designed to assist countries in developing and drafting policies, laws, regulations and contracts on ABS, and apply to all genetic resources and associated traditional knowledge, innovation and practices covered by the CBD and benefits arising from the commercial and other utilization of such resources, with the exclusion of human genetic resources (see Box 7.1).

In 2004, the Working Group on ABS was mandated by COP 7 to elaborate and negotiate an international regime on access to genetic resources and benefit sharing, with the aim of adopting an instrument/instruments to effectively implement the provisions in Article 15 and 8(j) of the CBD and the three objectives of the CBD. COP 9 in 2008 agreed on a road map and a basic framework including main components of the international regime and called for the Working Group to complete its negotiations at the earliest time possible before COP 10 in 2010. The relationship of the international regime to more sector-specific regimes such as the multilateral system for ABS in the ITPGRFA is also an important issue that needs to be further addressed.

7.2.3 ABS in relation to WTO, UPOV and WIPO

IPR offer one means to facilitate 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 WTO and in particular in the TRIPS Council. It has also been under discussion in the UPOV and the WIPO.

The TRIPS Agreement provides for periodical review of its implementation, and other reviews in the light of any relevant new developments that might warrant modifications of the Agreement. It has become apparent that there is a difference of opinion among TRIPS Council Members as to whether there is any inherent conflict between the TRIPS Agreement and the CBD, and if so how it could be resolved. One proposal that has been made in the TRIPS Council is to amend the TRIPS Agreement to require in national patent legislation the disclosure of the origin of genetic resources and/or associated traditional knowledge in patent applications.

Article 27.3(b) of the TRIPS Agreement authorises TRIPS members to exclude plants and animals other than micro-organisms from patentability, as well as essentially biological processes for the production of plants or animals. However TRIPS members are required to grant protection to plant varieties, either through patents, through an effective *sui generis*[2] system, or through a combination of both. The Article 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 Convention, which offers the advantage of mutual recognition among all UPOV members.[3] The UPOV Convention incorporates the principle of free access to improved varieties for further research and breeding (breeders' exemption). In its present form, the UPOV model would exclude the imposition of a requirement to disclose the origin of genetic resources as a condition for the granting of plant breeders' rights, since 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 traditional knowledge. At the request of COP 7, WIPO was invited to examine issues regarding the interrelationship of access to genetic resources and disclosure requirements in patent applications: the results of the examination were officially transmitted to COP8.

7.2.4 FAO and ABS

The FAO 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 AND REGIONAL LEVELS

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 CGIAR 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 CGIAR 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 status of ABS 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 or similar decentralized governmental systems, the allocation of responsibilities between a central or federal government and its individual states, regions 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 and regional 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.[10]

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.[11] Updated information on the accessions included in the Multilateral System is available at the Secretariat of the ITPGRFA.[12] A number of countries, including both developed and developing countries, as well as countries with economies in transition have provided information on material included in the Multilateral System[13]. The material includes some PGRFA held by private entities including, for example, at least two private breeders' associations in France.[14] EURISCO, The European catalogue of *ex situ* PGR collections, has been adapted to incorporate the inclusion of each accession in the Multilateral System.

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.[15]

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 Netherlands and Germany. The implementation of the Multilateral System in Germany 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, other countries have found that 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 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.[16] 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.[17]

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.[18]

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 SPC. The SPC is in the process of concluding an Agreement with the Governing Body under Article 15.5 of the ITPGRFA, placing the regional germplasm collection within the purview of the ITPGRFA.

TABLE 7.1
Experience of the CGIAR Centres with the SMTA 01 January 2007 to 31 July 2007 (first line) and 01 August 2007 to 01 August 2008 (second line)

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
7 264	95 783	348 973	444 824	3 267	-	0

Access and Availability of PGRFA under the Multilateral System: Table 7.1 provides information on 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.[19] Further information is provided on acquisition and distribution by CGIAR Centres during the year commencing 01 August 2007 as reported to the Third Session of the Governing Body.[20] 74% of the materials were distributed to developing countries and 6% to developed countries.

So far there is still little quantifiable information on the flow of germplasm from national sources, although it is clear that an increasing amount of PGRFA is now circulating under the Multilateral System. In particular it is understood that a number of countries, such as Canada, Egypt, Germany, the Islamic Republic of Iran, the Syrian Arab Repuplic, the Nordic countries and Netherlands, are now distributing Annex 1 materials widely 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.[21]

7.3.3.3 National and regional implementation of access and benefit-sharing 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'[22] 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[23] listed 30 countries[24] 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,[25] 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 and benefit sharing 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.[26] 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.

Benefit-sharing arrangements: 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.[27] 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.[28] 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.[29]

Traditional knowledge and the rights of indigenous and local communities: 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,[30] a proclamation in Ethiopia,[31] 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.[32] 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.[33] 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.[34] 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.[35]

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.

Disclosure of origin requirements have been enacted in the patent legislation of a number of European countries, including Belgium, Denmark, Germany, Norway, Sweden and Switzerland.

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; and their right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of PGRFA. The ITPGRFA does not limit any rights that farmers have to save, use, exchange, and sell farm-saved seed/propagating material, subject to national law.

Recent debates on the 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,[36] reviewed the state of implementation of Article 9 of the ITPGRFA 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.

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:

- 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 ABS that facilitates access to PGRFA of the most important crops and forages for food security. As of September 2009, there were 120 parties to the ITPGRFA;
- 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 before the 10th meeting of the Conference of Parties in 2010;
- Discussions on certain matters related to ABS are also taking place in other fora such as the TRIPS Council, WIPO and WHO;

- 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;
- 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 and other sectors;
- 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, regional or provincial 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;
- 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. Regulatory systems also need to be responsive to the needs of famers.

BOX 7.1

Benefit sharing under the International Treaty on Plant Genetic Resources for Food and Agriculture

Under the ITPGRFA, 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:

The exchange of information: 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.

Access to and transfer of technology: 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.

Capacity building: 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.

Sharing of monetary and other benefits arising from commercialization: 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 available for further research and breeding, for example as a result of certain types 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 1.1% of the gross sales generated by the product less 30% (i.e. 0.77%).

BOX 7.2

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;

BOX 7.2 *(continued)*

Potential benefit from access and benefit sharing as listed in the Bonn Guidelines

(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 7.3

Implementing the Multilateral System through administrative measures – The experience of one Contracting Party

The following account is drawn from the experience of one Contracting Party, but reflects the experience of a number of countries. In the example cited, the responsibility for PGRFA is shared between the Federal and State 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 a **National Programme** on Plant Genetic Resources, by an A**dvisory and Co-coordinating Committee**, and by a **National Inventory** for Plant Genetic Resources.

As a **first step** in implementation of the Multilateral System, 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 States and/or local authorities were **requested** to introduce the SMTA;
- All other collections (mixed, private) were **invited** to introduce the SMTA.

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 Multilateral System flag.

The case study draws the following lessons from the national experience:

- Early and comprehensive information of the relevant stakeholders on the national implementation of the Multilateral System 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 Multilateral System and the SMTA at national level.
- General guidelines on how to include material in the Multilateral System at the collection level (e.g., identification of public domain accessions) could be helpful.

[1] Article 13.6 requires the Contracting Parties to consider modalities of a strategy of voluntary benefit-sharing contributions from Food Processing Industries that benefit from plant genetic resources for food and agriculture.

[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] Article 5.2 of the International Convention for the Protection of New Varieties of Plants, 1961, as revised in 1972, 1978, and 1991.

[4] CGRFA-11/07/Report. Available at: ftp://ftp.fao.org/docrep/fao/meeting/014/k0385e.pdf

[5] For example, Morocco, Nepal, Spain, Sri Lanka and Uruguay.

[6] Available at: http://km.fao.org/gipb/

[7] **Young, T**.2004. Legal issues regarding the international regime: objectives, options and outlook. *In* Carriosa, S.,Brush, S., Wright, B. and McGuire, P (Eds.) *Accessing Biodiversity and Sharing the Benefits: Lessons from Implementing the Convention on Biological Diversity*. IUCN Environmental Policy and Law Paper No. 54, 2004, pp. 271-293.

[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] For example, the. Acre State Law - Accesso a recursos genéticos lei estadual, 1997, and Amapá State Law on Access to Genetic Resources, 1997.

[10] 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).

[11] Notification from the ITPGRFA Secretariat dated 11 June 2008. Available at: ftp://ftp.fao.org/ag/agp/planttreaty/noti/csl806e.pdf

[12] Available at: http://www.planttreaty.org/inclus_en.htm

[13] Available at: http://www.planttreaty.org/inclus_en.htm

[14] Review of the Implementation of the Multilateral System, FAO Doc. IT/GB-3/09/13.

[15] For example, the country reports of Germany and Netherlands. It is also reported that the United Kingdom has also successfully encouraged government-supported institutions to place their collections in the Multilateral System.

[16] 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.

[17] For example, Morocco, Sudan and Syria.

[18] For an account of AEGIS, see http://www.ecpgr. cgiar.org/AEGIS/AEGIS_home.htm

[19] 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.

[20] 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.

[21] Review of the Implementation of the Multilateral System, FAO Doc. IT/GB-3/09/13.

[22] Available at: http://www.norden.org/pub/miljo/jordogskov/sk/ANP2004745.pdf

[23] Available at: http://www.cbd.int/abs/measures.shtml

[24] Country reports: 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, Philippines, Portugal, South Africa, Uganda, Vanuatu, Venezuela and Zimbabwe.

[25] For example, the country reports of Bhutan, Brazil, Bulgaria, Costa Rica, Ethiopia, Malawi and Philippines.

[26] For example, the country reports of Afghanistan, Algeria, Albania, Armenia, Dominica, Dominican Republic, Fiji, Ghana, Jordan, Lao PDR, Lebanon, Madagascar, Malawi, Malaysia, Mali, Morocco, Namibia, Nepal, Nigeria, Oman, Pakistan, Palau, Russian Federation, Tajikistan, United Republic of Tanzania, Thailand, Trinidad & Tobago, Uruguay, Viet Nam and Zambia.

[27] **Young, T.** 2004. Op.cit. Endnote 7, .p. 275.

[28] For example, **Laird, S. and Wynberg, R.** 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.

[29] Law No. 27811 of August 2002, Articles 8 and 27 (c).

[30] 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. Available at: http://www.opbw.org/nat_imp/model_laws/oau-model-law.pdf

[31] Proclamation No. 482/2006 on Access to Genetic Resources and Community Knowledge, and Community Rights.

[32] Law No. 27811 establishing the Protection Regime for Collective Knowledge of Indigenous Peoples Connected with Biological Resources, 2002.

[33] Decree-Law No. 118/2002.

[34] For example, COP decisions II/11 and III/15.

[35] 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 concern by developing countries for an international mechanism to ensure compliance with the terms and conditions of the SMTA.

[36] FAO, 2009. Report of the governing body of the ITPGRFA, Third Session. Tunis, Tunisia, 1-5 June 2009 IT/GB-3/09/Report.

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. On the one hand yields per unit area have increased dramatically through a combination of improved crop varieties and a greater use of external inputs,[1] but on the other hand there has been increasing pressure on land for uses other than the production of food, as well as growing concerns about the sustainability and safety of some modern practices.

In spite of advances in food production, food insecurity and malnutrition are 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. A major share of this productivity increase will have to come from the use of PGRFA to produce higher yielding, more nutritious, more stable and more eco-efficient crop varieties.

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 (MDG) (see Box 8.1). All countries and all of the world's leading development institutions have agreed to these goals, two of which, in particular, will require the conservation and use of PGRFA if they are to be reached: 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 United Nations Conference on Environment and Development (UNCED) in 1992 and the subsequent World Summit on Sustainable Development (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]

Within the context of overall sustainable development agricultural systems are extremely important. There are, however, many concerns about the non-sustainability of many agricultural practices, for example: the over-use or misuse of agrochemicals, water, fossil fuels and other inputs; the shifting of production to more marginal land and encroachment into forested areas; and the increased use of monocropping, more uniform varieties, and a reduced use of crop rotations. 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: 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 lie at the heart of 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 for breeding new crop varieties to meet a variety of challenges.

A large number of the country reports expressed concern about the increasing use of genetically uniform varieties and the trend for them to be grown on ever larger areas, resulting in increased genetic vulnerability (see section 1.3). Many 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 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 even result in higher 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 next year. In order to be able to continually adapt agriculture to ever changing conditions, plant breeders 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 maintain a full pipeline.

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 of plant breeders to access and use it. While genetic diversity represents a 'treasure chest' of potentially valuable traits, as shown elsewhere in this report, it is 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 a strong capacity to use it, especially in the developing world (see Chapter 4).

8.2.2 Ecosystem services and PGRFA

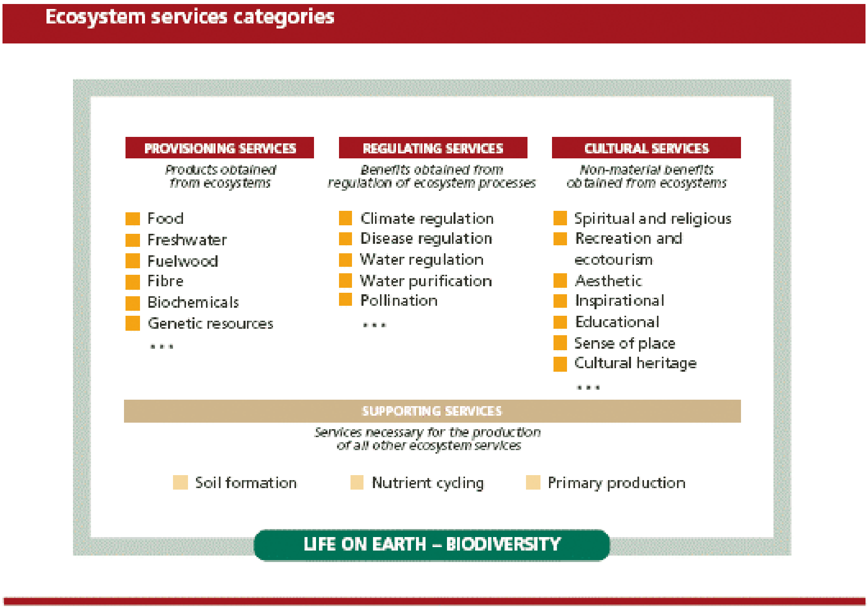
Agriculture contributes to development not only as an economic activity and as a source of livelihoods, but is also an important provider of environmental services.

Figure 8.1 illustrates the four broad categories of services provided by ecosystems:

- 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 of the four categories. In addition to being a direct 'provisioning service', genetic resources provide the raw material for improving the production of more and better food, either directly or through providing better feed for livestock. They are also important as the basis for improving fibre, fuel or any other

FIGURE 8.1
Categories of ecosystem services



Source: Adapted from Ecosystem and humand well-being: a framework for assessment by the Millennium Ecosystem Assessment. Copyright © 2003 World Resources Institute. Reproduced by permission of Island Press, Washington, DC.

crop product. In the area of 'regulating services,' PGRFA are the basis for improving such services as carbon sequestration by crops - for example deeper-rooted rangeland species - and the control of water run-off and soil erosion. The diversity of traditional crops and foods can provide an important cultural service, e.g. through its importance in agrotourism or 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 to 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 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. This is particularly true in the case of agrobiodiversity. If, for instance, the 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 that the expected service is actually provided. This is a dilemma that also underlies the debate over how to implement Farmers Rights (see Chapters 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.

8.3 PGRFA AND FOOD SECURITY

Food security and related 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.[6] 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.[7] The PGRFA sector has multiple roles to play in helping ensure 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. There is, however, need for a greater recognition of the multiple roles and contributions that PGRFA can play and for a strengthening of the linkages among all relevant institutions dealing with food security at the global, regional, national and the local levels.

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 demand of a population that is projected to expand by some 40 percent over the period from 2005 to 2050. According to one projection by FAO, an additional billion tonnes of cereals will be needed annually by 2050. Since on average, only 16%[8] (15% of cereals and 12% of meat) of the world's agricultural production enters international trade, much of the increase will have to be met through expanding production in those, mainly developing countries that experience the greatest increase in demand.

Many country reports from all regions have documented the vital role of sound PGRFA management in strengthening national food security and improving livelihoods. 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. Yield increases of 10% and more were associated with each replacement, and with every 10% yield increase, the level of poverty was reduced by 6 to 8%.[9] According to Malawi's 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 helped to boost local industry such as the fabrication of cassava processing equipment, increased the use of cassava in livestock feed and provided funds for the development of local on farm seed programmes.[10]

Recent experience with crop productivity growth gives reason for both optimism and concern. When growth in yield per unit area 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 8.2). Maize and rice productivity have continued to increase on a world scale, although rice yield increases have also levelled off in East and Southeast Asia. In Africa, yields of major crops like rice, maize and wheat are still far below those typically seen in other regions. However, good progress is being made, for example through the development and fast dissemination of NERICA[11] rice (see Box 8.3). While much of the yield increase is attributable to a combination of factors including an increased use of inputs and good weather conditions, a major factor has 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.

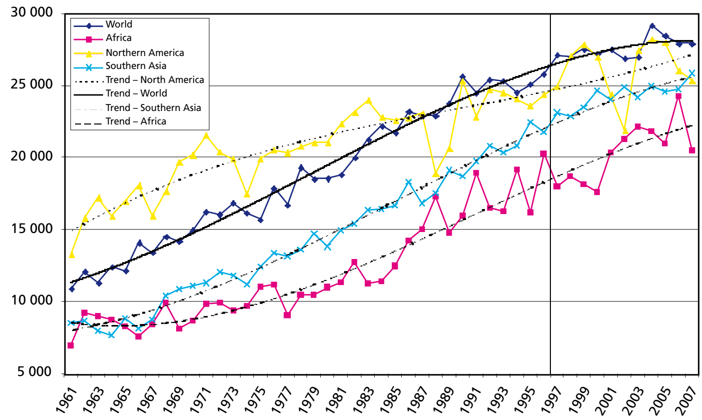
8.3.2 Use of local and indigenous PGRFA

While local landraces and farmers' varieties provide the genetic diversity that underpins much modern plant breeding, for many agrarian countries such varieties still provide the basis for local food production and security. Indeed this generally remains their main use in situations where they are still grown by the communities that developed them. Furthermore they may have a number of advantages, especially in the absence of appropriate alternatives: they are adapted to local environmental conditions, fit in with local farming systems, meet local taste and other preferences and their diversity can bring greater production stability. Local varieties may also command premium 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 Viet Nam, 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 cope with environmental heterogeneity, combat the effects of pests and diseases, meet cultural and ritual needs, and satisfy 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

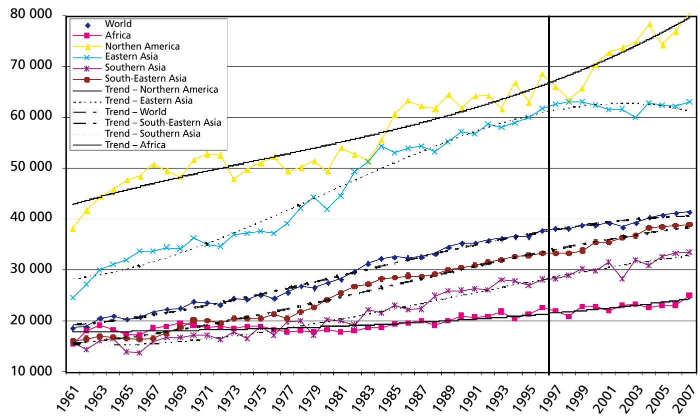
FIGURE 8.2

Average yields (kg/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)

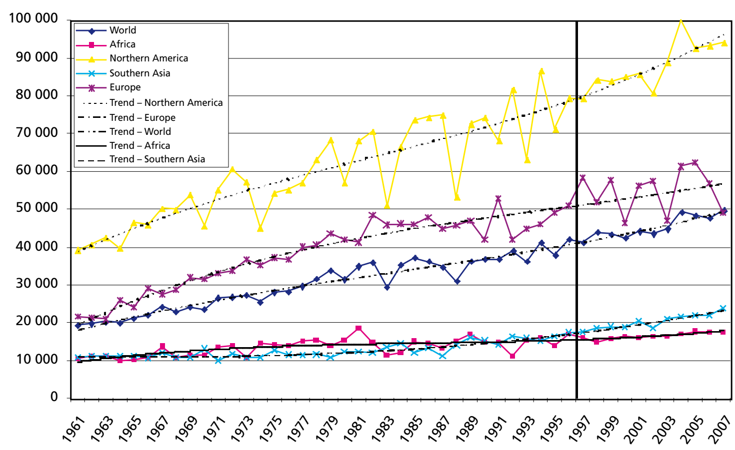
a) Wheat



b) Paddy rice



c) Maize



Source: Faostat (http://faostat.fao.org) 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 local crops. The international Slow Food movement[16], for example, has had a significant impact in raising awareness in many developed countries of the role of traditional food in local culture, the nutritional value of many local foods, and the importance of dietary diversity and reduction of '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 related to the place of origin.[17] Finally, organic crop production, requiring varieties that are adapted to organic growing conditions, has gained in importance globally, and is often associated with initiatives that aimed to promote traditional and local food.

8.3.3 Climate change and 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 enormous. This topic was the main theme of the seminar held in 2009 on the occasion of the First Anniversary of the SGSV. The importance of taking immediate action was addressed in a Summary Statement arising from the seminar[18] that concluded: "*…we ask the nations of the world to recognise the urgency of adapting agriculture to climate change, that crop diversity is a prerequisite for this adaptation, and therefore that the importance of ensuring that the genetic diversity of our crops is properly conserved and available is a basic prerequisite for feeding a warming world*"

Prediction models of the IPCC[19] as well as other reports[20] indicate that there will be severe effects on agricultural productivity in many 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 will become more productive, as long as high yielding varieties are available that are adapted to the new environmental conditions.

Unfortunately, it is expected that regions such as South Asia and Southern Africa are likely to be most affected by climate change; areas of the world that are home to the largest number of poor people and that are least able to cope.[21] In many regions adapting agriculture to the new conditions will require a shift to more drought-tolerant or heat-tolerant varieties or even to other crops. Changes in pest and disease patterns are likely to take place and indeed may be already happening, resulting in the need for new resistant or tolerant varieties. Less predictable weather patterns may also require the development of new varieties that are adapted to a wider range of more extreme conditions.

New varieties will also be needed for agriculture to be able to play a greater role in mitigating climate change. For example, varieties with greater biomass, e.g that are deeper rooting, coupled with appropriate agronomic practices, can result in the capture of more carbon in the soil. Feed and forage varieties can be bred that result in less methane being emitted by ruminants, and varieties that are able to use nitrogen more efficiently are expected not only to need less fertilizer and hence less total energy but also result in reduced emissions of the potent greenhouse gas nitrous oxide. Although bioenergy crops were mentioned in only relatively few 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.

Overall the difficulties of mitigating against and adapting to climate change are likely to make it considerably more difficult to meet the increased demand for food in the future. The challenge will be exacerbated further by growing competition for land for other uses, such as urban development or for growing new crops. In order to meet such challenges it is essential that greater attention be devoted to conserving genetic diversity, and in particular to targeting the collection and conservation of landraces and crop wild relatives that have traits that are likely to become more important in the future. Coupled with this, it is essential that plant breeding efforts be stepped up around the world, and especially in those developing countries likely to be hardest hit by climate change. This will require greatly enhanced attention to capacity building in traditional as well as modern plant genetic improvement techniques.

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.[22] Gender differences are further evident in varietal choices and the importance placed on different traits. Research in United Republic of Tanzania, for example, showed differences between male and female farmers in the different importance and ranking they gave to various traits in sorghum.[23]

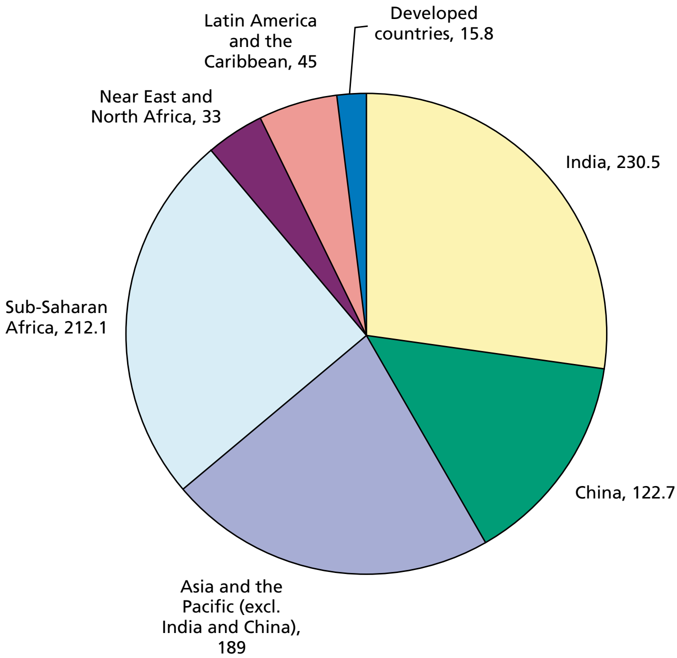
While overall this did not come across clearly in the country reports, it is critical that the role of rural women be better understood and taken into account in policy making and in all relevant PGRFA initiatives.

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 SSA. 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 8.3).

PGRFA underpin not only total food production but also nutritional wellbeing (see section 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.[24]

FIGURE 8.3
Number of undernourished people in the world, 2003-2005 (millions)



Source: FAO, 2008, The State of Food Insecurity in the World, Rome

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 an extremely important source of pharmaceutical products and, as for all crops, the current production of medicinal crops as well as their 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.[25] 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.[26]

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 section 4.9.2). By definition, the area sown to these crops is relatively small worldwide;[27] 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 change.[28] 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 use 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[29] as well as efforts to promote and market them.[30]

While much has been done in this area, much more still needs to be done in particular in developing markets for the products of neglected species. Efforts of institutions such as Crops for the Future (see section 6.3.3)[31] 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

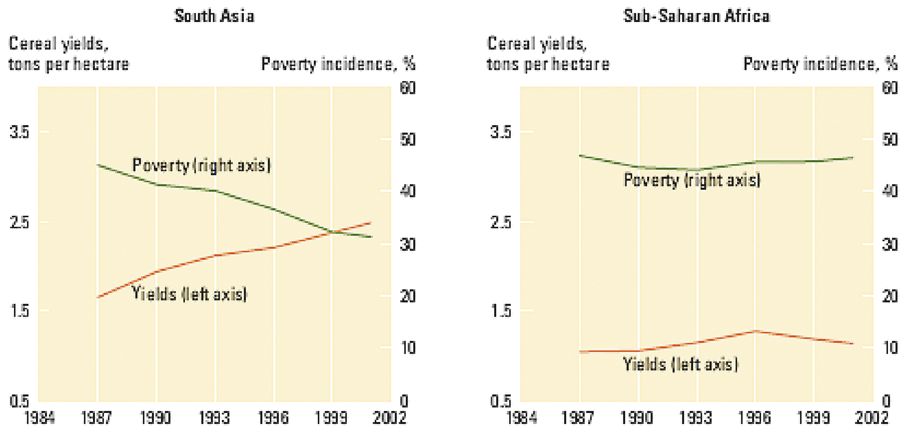
The economic health and prosperity of a country depends on a large number of factors of which agricultural productivity and growth is one. The importance of agriculture varies by region, from only 1.9% of the population dependent on agriculture in North America to over 50% in Africa and Asia. However, 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[32] 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 SSA where agricultural yields have generally stagnated, making it more difficult to clearly establish a relationship with poverty reduction (see Figure 8.4).

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 seed of new and appropriate varieties. 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

FIGURE 8.4
Cereal yield and poverty in South Asia and Sub-Saharan Africa



Source: Ravallion and Chen 2004; World Bank 2006

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.[33] 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,[34] for example, it was estimated that conserving 1,000 accessions of rice generates an annual income stream for developing countries that has 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.[35] The impact has been both direct and indirect: high yields generating higher incomes, but also generating employment opportunities and lower food prices.[36]

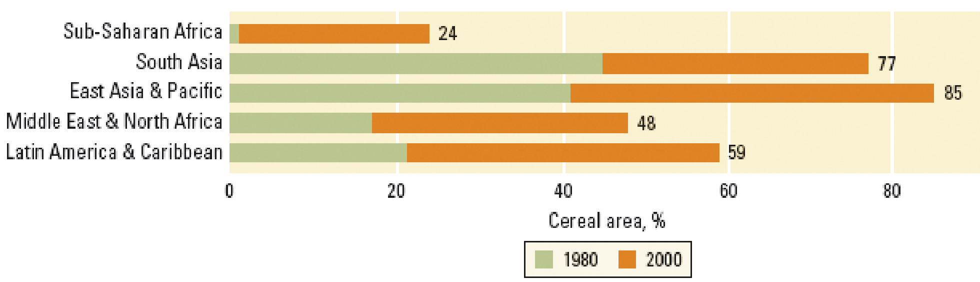
However, in a study across 11 food crops in four regions over the period 1964-2000,[37] it was concluded that the contribution of modern varieties to productivity increases was a 'global success, but for a number of countries a local failure.' Many of these countries are located in SSA where adoption 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 SSA, although relatively small, has been almost completely attributable to modern varieties, with little contribution from fertilizer and other inputs.[38]

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.[39] 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[40] it was found that the poorest people 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 local seed systems; it is grown for multiple purposes and 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 have been shown to contribute significantly to poverty reduction, they have arguably been less successful in enhancing the sustainable agricultural development of small-farm systems, especially in more marginal production environments. Key shortcomings cited have been a lack of adaptation to heterogeneous and harsh production areas[41] 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.

FIGURE 8.5
The growth in area under improved cereal varieties in 1980 and 2000



Source: World Bank, 2007

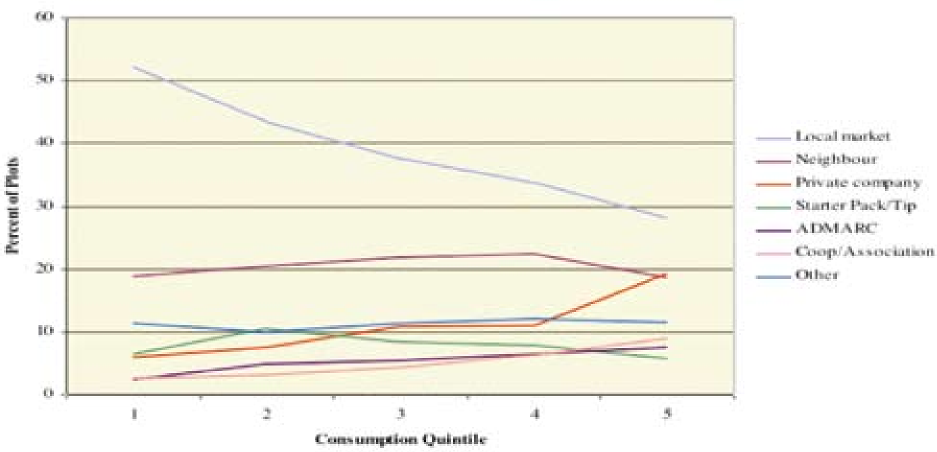
8.4.2 Diversification and the use of genetic diversity

The choice of which crops and varieties to plant is driven by a range of economic, social, and agronomic factors, including the availability of suitable market outlets, prices, familiarity and societal acceptance, costs of production, the need for and availability of production inputs (including seed, 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[42] have shown that household farms in most developing countries produce both for their own consumption as well as for sale,[43,44] 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 achieve food and income security.[45] 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 and at the farm level, a diversity of enterprises can be undertaken, e.g. food processing, meat or egg production, agroforestry or agrotourism. Many of these strategies 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.[46] 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.

FIGURE 8.6
Seed sources by consumption group in Malawi (1=poor; 5=rich)



Source: Elaboration from Stella Nordhagen elaboration using RIGA data set

8.4.3 Access to seed

Section 4.8 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.[47] 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.

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.[48] Many country reports stressed the need for stronger seed production and distribution systems as well as for greater harmonization between the commercial and farmers' seed sectors.

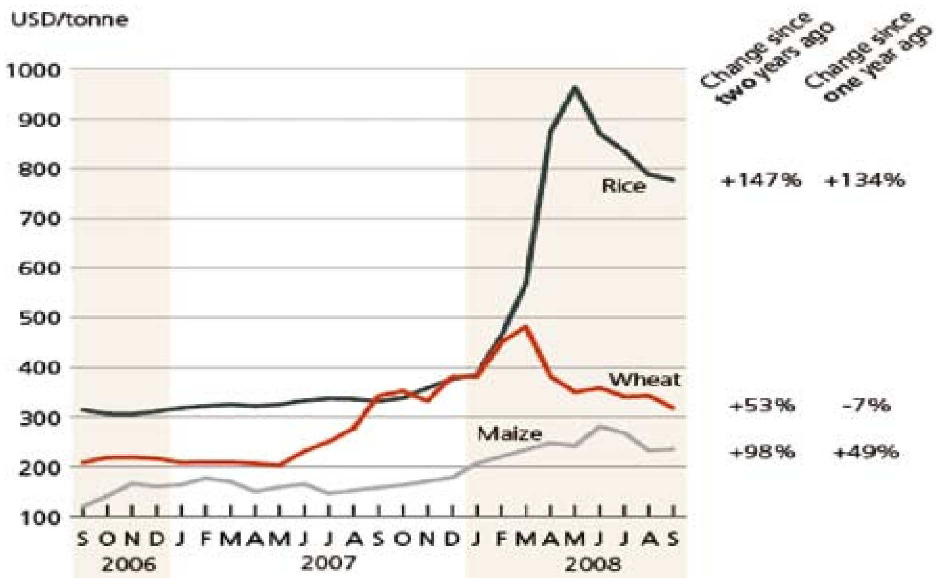
8.4.4 Globalisation and PGRFA

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 need and the resources to access new varieties. Moreover, a growing share of produce from the small-scale sector is now reaching local, national and even international markets. The privatization of breeding has continued (see section 4.4) 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 Figure 8.7). 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 biofuels, speculation on futures markets, the imposition of export restrictions and a lack of investment in the agricultural sector.[49] 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 MDG of eradicating poverty and hunger. In late 2007 FAO launched the Initiative on Soaring Food Prices (ISFP) in response to these sudden price increases (see Box 8.2).

While 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 helping the world's poorest people survive and thrive in a world of increasing globalization through helping to expand and stabilize food production and increase the incomes of many of the world's poorest people.

FIGURE 8.7
Volatility of international cereal prices



Source: Views, global information and early warning system on food and agriculture

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 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 the new varieties that will be needed for agriculture to adapt to the anticipated 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' 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 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;[50]
- Organic agricultural production is receiving greater attention in response to increasing concerns by consumers regarding their diet, health and the environment;
- In spite of the on-going controversy, GM-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:

- The growing consensus on the nature, extent and rate of climate change makes it imperative that far greater attention be paid to anticipating and preparing for its effects. Given the time needed to breed a new crop variety (around ten years), it is essential that additional plant breeding capacity be built now, especially in developing countries, and that breeding programmes expand their efforts to develop the traits and varieties needed to meet the challenge;
- There is also a need to step up efforts to conserve landraces, farmers' varieties and CWR before they are lost as a result of changing climates. Special efforts are needed to identify those species and populations that are most at risk and that are most likely to harbour traits that will be important in the future;
- There is a need for more efficient, strategic and integrated approaches to the management of PGRFA at the national level. Links need to be strengthened between those individuals and institutions in both the private and public sectors who are

primarily responsible for conservation, and those who are primarily concerned with genetic improvement and seed production and distribution;

- At the international level there is also a need for greater coordination and cooperation among agencies and institutions concerned with international and intergovernmental aspects of the conservation and use of PGRFA and those concerned with agricultural production, protection, sustainability and food security, as well as related areas such as health and the environment;
- Although much progress has been made, enhanced South-South cooperation has the potential to contribute much more to the conservation and use of PGRFA, and to strengthening its role in achieving food security and sustainable agricultural development;
- 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, to assess the impact of its use and to bring this information to the attention of policy makers and the general public so as to help generate the resources needed to strengthen programmes for its conservation and use;
- 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;
- 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 the products of neglected and under-utilized crops, leading to greater dietary diversity. Better access by resource poor farmers to markets and strengthened market information systems are needed.

BOX 8.1

The 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 in 2008 and 2009 , 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 to increase smallholder access to markets;

(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.

BOX 8.3
NERICA rice

The term NERICA, 'New Rice for Africa', is used to refer to genetic material derived from the successful crossing by WARDA in the early 1990s, of the two species of cultivated rice, the African rice (*O. glaberrima* Steud.) and the Asian rice (*O. sativa* L.), to produce progeny that combine the high yielding traits from the Asian parent and the ability to thrive in harsh environments from the African parent. The *O. glaberrima* accessions used in the breeding programme came from the WARDA genebank and simple biotechnological techniques (another culture and double-haploidization) were used to overcome sterility barriers with *O. sativa*.

NERICA is a new group of rice varieties that adapt well to rainfed ecologies in SSA, where 70% of smallholder farmers cultivate rice. The new varieties have a higher yield potential than the traditional varieties grown and have spread at record rates, covering more than 200,000 hectares in West, Central, East and Southern Africa by 2006. The NERICA varieties offer hope to millions of poor rice farmers and consumers.

[1] Progress report on the Sustainable Agriculture and Rural Development (SARD) Initiative to the Committee on Agriculture of FAO and the UN Commission on Sustainable Development on progress of the Initiative, 2006.

[2] World Summit on Sustainable Development, 2002.

[3] Millennium Ecosystem Assessment, (2005), Ecosystems and Human Well-being: Synthesis, Island Press, Washington, DC.

[4] Country Report: Pakistan

[5] Near East and North Africa Regional Synthesis of Plant Genetic Resources for Food and Agriculture, 2008.

[6] Right to Food Voluntary Guidelines.

[7] FAO. 2001. The State of Food Insecurity in the World.

[8] Measured as: (gross imports + gross exports) / 2 * production.

[9] Country Report: China.

[10] Country Report: Malawi.

[11] NERICA: New Rice for Africa. See, for example, http://www.warda.org/NERICA%20flyer/technology.htm

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[14] Country Report: Portugal.

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[16] Available at: http://www.slowfood.com/

[17] See, for example, http://www.origin-gi.com

[18] Available at: http://www.regjeringen.no/upload/LMD/kampanjeSvalbard/Vedlegg/Svalbard_Statement_270208.pdf

[19] Available at: http://www.ipcc.ch/

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[22] 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).

[23] LinKS [Gender, Biodiversity and Local Knowledge Systems for Food Security] 2003. Proceedings of the National Workshop on Sharing and Application of Local/Indigenous Knowledge in Tanzania. LinKS Report No. 5. Rome.

[24] For example, see: http://www.harvestplus.org

[25] Country Report: Kenya

[26] For example, see: http://www.who.int/mediacentre/en/

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[28] Country reports: Azerbaijan, Bangladesh, China, Dominica, Ethiopia, Georgia, India, Indonesia, Jamaica Malawi, Pakistan, Romania, Sri Lanka, Uganda, Yemen, Zambia and Zimbabwe.

[29] Country reports: Ghana, Hungary, India, Pakistan and Yemen.

[30] Country reports: Argentina, Bolivia, Costa Rica, Cuba, Dominican Republic, Ecuador, Jamaica, Palau, Saint Vincent and the Grenadines and Zimbabwe.

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ANNEX 1

Regional distribution of countries

AFRICA

Sub-region	Country
Central Africa	Cameroon, Central African Republic, Democratic Republic of Congo, Congo, Equatorial Guinea, Gabon, Sao Tome and Principe
East Africa	Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, Sudan, Uganda
Indian ocean island	Comoros, Madagascar, Mauritius, Réunion, Seychelles
Southern Africa	Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, United Republic of Tanzania, Zambia, Zimbabwe
West Africa	Benin, Burkina Faso, Cape Verde, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo

AMERICAS

Sub-region	Country
Caribbean	Antigua and Barbuda, Bahamas, Barbados, Belize, Cuba, Dominica, Dominican, Republic, Grenada, Guyana, Haiti, Jamaica, Puerto, Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago
Central America and Mexico	Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama
North America	Canada, United States of America
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela

ASIA AND THE PACIFIC

Sub-region	Country
East Asia	China, Japan, Democratic People's Republic of Korea, Republic of Korea, Mongolia
Pacific Region	Australia, Cook Islands, Fiji, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu
South Asia	Bangladesh, Bhutan, India, Maldives, Nepal, Sri Lanka
Southest Asia	Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam

EUROPE

Sub-region	Country
Eastern Europe	Albania, Armenia, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Republic of Moldova, Russian Federation, Serbia, Slovakia, Slovenia, The Former Yugoslav Republic of Macedonia, Ukraine
Western Europe	Andorra, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Liechtenstein, Luxembourg, Monaco, Netherlands, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, United Kingdom

NEAR EAST

Sub-region	Country
Central Asia	Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan
South/East Mediterranean	Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Libyan Arab Jamahiriya, Malta, Morocco, Palestinian Authority, Syrian Arab Republic, Tunisia
West Asia	Afghanistan, Bahrain, Islamic Republic of Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, Turkey, United Arab Emirates, Yemen

APPENDIX 1

Status by country of national legislation related to PGRFA

LEGEND:

X	Legislation adopted before 1 January 1996
X	Legislation adopted after 1 January 1996
Y	Part of broader legislation adopted before 1 January 1996
Y	Part of broader legislation adopted after 1 January 1996
O	Draft or ongoing legislation
Z	Part of a broader draft or ongoing legislation
P	Party to the treaty or convention before 1 January 1996
P	Party to the treaty or convention since 1 January 1996
S	Signatory of the treaty or convention before 1 January 1996
S	Signatory of the treaty or convention since 1 January 1996
Regional	Regional agreement (this information is given only when the country that has signed the regional agreement has not adopted national legislation)

AFRICA, SOUTH OF SAHARA

WEST AFRICA

Countries[1]	Agricultural biodiversity including access to plant genetic resources and seeds					Plant Protection		Intellectual Property Rights				Biosafety	
	International		National			International	National	International		National		International	National
	ITPGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Benin	P	P			X		X		P	Regional		P	X
Burkina Faso	P	P			X	P	X		P	Y		P	X
Cape Verde	S	P				P	X		P			P	O
Chad	P	P				P	X		P	Regional		P	O
Côte d'Ivoire	P	P			X	P	X		P	Regional			O
Gambia		P	Y				X		P			P	O
Ghana	P	P		O	X	P	X		P	O		P	O
Guinea-Bissau	P	P			X	P	X		P	Regional			O
Guinea	P	P				P	X		P	Regional		P	O
Liberia	P	P				P	X					P	O
Mali	P	P			X	P	X		P	Regional		P	O
Mauritania	P	P			X	P	X		P	Regional		P	
Niger	P	P			X	P	X		P	Regional		P	O
Nigeria	S	P	Y		X	P	X		P			P	O
Senegal	P	P			X	P	X		P	Regional		P	O
Sierra Leone	P	P				P	X		P				O
Togo	P	P				P	X		P	Regional		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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Cameroon	P	P			X	P	X		P	Y		P	X
Central African Republic	P	P				P	X		P	Regional		P	O
Congo, Democratic Republic of	P	P					X		P			P	O
Congo	P	P				P	X		P	Regional		P	O
Equatorial Guinea		P				P				Regional			
Gabon	P	P				P	X		P	Regional		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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Angola	P	P	X		X				P				
Botswana		P			X	P	X		P			P	O
Lesotho	P	P	Y						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	Z	P	O		P	O		P	X
South Africa		P	X		X	P	X	1978	P	X		P	X
Swaziland	S	P			X	P	X		P		X	P	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	Y		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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	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					P	O
Ethiopia	P	P	X	O	X	P	X			O		P	O
Kenya	P	P	X		X	P	X	1978	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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Argentina	S	P	O		X	P	X	1978	P	X		S	Y
Bolivia		P	X		X	P	X	1978	P	X		P	X
Brazil	P	P	X	Y	X	P	X	1978	P	X		P	X
Chile	S	P	O		X	S	X	1978	P	X		S	X
Colombia	S	P	X		X	P	X	1978	P	X		P	X
Ecuador	P	P	Z		X	P	X	1978	P	X		P	O
Paraguay	P	P	Y	Y	X	P	X	1978	P	X		P	X
Peru	P	P	X		X	P	X		P	X		P	X
Uruguay	P	P	O		X	P	X	1978	P	X		S	X
Venezuela	P	P	X		X	P	X		P		X	P	X

CENTRAL AMERICA AND MEXICO

Countries[1]	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[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Costa Rica	P	P	X	Y	X	P	X	1991	P	X		P	X
El Salvador	P	P			X	P	X		P		X	P	X
Guatemala	P	P	Y		X	P	X		P	O		P	X
Honduras	P	P			X	P	X		P			P	X
Mexico		P	X		X	P	X	1978	P	X		P	X
Nicaragua	P	P	Y		X	P	X	1978	P	X		P	O
Panama	P	P	X		X	P	X	1978	P	X		P	X

CARIBBEAN

Countries[1]	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[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	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

CARIBBEAN *(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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Belize		P				P	X		P		X	P	X
Cuba	P	P	Y	Y	X	P	X		P		X	P	X
Dominica		P				P	X		P		X	P	O
Dominican Republic	S	P	O		X	P	X	1991	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		P		O	P	O
Suriname		P				S	X		P			P	O
Trinidad and Tobago	P	P				P	X	1978	P	X		P	

NORTH AMERICA

Countries[1]	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[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Canada	P	P			X	P	X	1978	P	X		S	Y
United States of America	S	S			X	P	X	1991	P	X			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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	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				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

SOUTHEAST 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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)3	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Brunei		P	Regional				X		P				
Cambodia	P	P	Regional			P	X		P			P	O
Indonesia	P	P	Y		X	P	X		P		X	P	X
Lao PDR	P	P	Regional		X	P	X					P	
Malaysia	P	P	O	Y	X	P	X		P	X		P	X
Myanmar	P	P	Regional		O	P			P			P	O
Philippines	P	P	X	O	X	P	X		P	O	X	P	X
Singapore		P	Regional		X		X	1991	P	O	X		
Thailand	S	P	Y	Y	X	P	X		P		X	P	O
Viet Nam		P	Y		X	P	X	1991	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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
China		P	Y		X	P	X	1978	P	X		P	X
Japan		P			X	P	X	1991	P	X		P	X
Korea, Dem. People's Republic of	P	P				P	X					P	O
Korea, Republic of	P	P	Y		X	P	X	1991	P	X		P	X
Mongolia		P				P			P			P	O

PACIFIC REGION

Countries[1]	Agricultural biodiversity including access to plant genetic resources and seeds – International: IT-PGRFA	International: CBD	National: Access and benefit-sharing[2]	National: Farmers' rights	National: Seed certification	Plant Protection – International: IPPC	National: Phytosanitary	Intellectual Property Rights – International: UPOV (Latest Act)[3]	International: TRIPS - WTO	National: PBR[4]	National: PVP[5]	Biosafety – International: Cartagena Protocol on Biosafety	National: Biosafety regulations
Australia	P	P	Y		X	P	X	1991	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						P	
New Zealand		P	O			P	X	1978	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	Y			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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Austria	P	P	Y	Y	X	P	X	1991	P	X		P	X
Belgium	P	P			X	P	X	1972	P	X		P	X
Denmark	P	P	Regional		X	P	X	1991	P	X		P	X
Finland	P	P	Regional		X	P	X	1991	P	X		P	X
France	P	P		Y	X	P	X	1978	P	X		P	X
Germany	P	P	Y	Y	X	P	X	1991	P	X		P	X
Greece	P	P	X		X	P	X		P	Regional		P	Y
Iceland	P	P	Regional			P	X	1991	P	O	X	S	
Ireland	P	P			X	P	X	1978	P	X		P	X
Italy	P	P	X	X	X	P	X	1978	P	X		P	X
Liechtenstein		P							P				
Luxembourg	P	P			X	P	X		P	Regional		P	X
Monaco		P										S	
Netherlands	P	P			X	P	X	1991	P	X		P	X
Norway	P	P	Z		X	P	X	1978	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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Portugal	P	P	X		X	P	X	1978	P	X		P	X
San Marino		P											
Spain	P	P			X	P	X	1991	P	X		P	X
Sweden	P	P	Regional		X	P	X	1991	P	X		P	X
Switzerland	P	P			X	P	X	1991	P	X		P	X
United Kingdom	P	P			X	P	X	1991	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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Albania		P	Y		X	P	X	1991	P	X		P	O
Armenia	P	P			X	P	X		P		X	P	O
Belarus		P			X	P	X	1991		X		P	X
Bosnia and Herzegovina		P				P				O	X		O

EASTERN 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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Bulgaria	P	P	Y			P	X	1991	P	X		P	X
Croatia	P	P			X	P	X	1991	P	X		P	O
Czech Republic	P	P	X		X	P	X	1991	P	X		P	X
Estonia	P	P		Y	X	P	X	1991	P	X		P	X
Georgia		P			X	P	X	1991	P	X		P	O
Hungary	P	P	X		X	P	X	1991	P	X		P	X
Latvia	P	P			X	P	X	1991	P	X		P	X
Lithuania	P	P	Y		X	P	X	1991	P	X		P	X
Macedonia, Former Yugoslav Rep. of	S	P			X	P	X		P	O		P	X
Moldova, Rep. of		P			X	P	X	1991	P	X		P	X
Montenegro		P								O	X	P	
Poland	P	P			X	P	X	1991	P	X		P	X
Romania	P	P			X	P	X	1991	P	X		P	X
Russian Federation		P			X	P	X	1991		X			X
Serbia	S	P			X	P	X			O	X	P	X
Slovakia		P	X		X	P	X	1991	P	X		P	X
Slovenia	P	P			X	P	X	1991	P	X		P	X
Ukraine		P	O		X	P	X	1991	P	X		P	X

NEAR EAST

SOUTH/EAST MEDITERRANEAN

Countries[1]	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[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Algeria	P	P			X	P	X				X	P	O
Cyprus	P	P			X	P	X		P		X	P	X
Egypt	P	P	Y		X	P	X		P	O	X	P	X
Israel		P			X	P	X	1991	P	X			X
Jordan	P	P	O		X	P	X	1991	P	X		P	O
Lebanon	P	P	O		X	P	X						O
Libyan Arab Jamahiriya	P	P				P	X					P	O
Malta	S	P			X	P	X		P		X	P	X
Morocco	P	P	O		X	P	X	1991	P	X		S	O
Syrian Arab Republic	P	P	O		X	P	X					P	X
Tunisia	P	P	O		X	P	X	1991	P	X		P	O

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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Afghanistan	P	P	Y		X								
Bahrain		P				P	X		P		X		
Iran, Islamic Republic of	P	P		O	X	P	X				X	P	O
Iraq					X	P					X		
Kuwait	P	P				P			P				
Oman	P	P				P	X		P	X		P	O
Pakistan	P	P	O	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	Y	O	X	P	X	1991	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
Countries[1]	IT-PGRFA	CBD	Access and benefit-sharing[2]	Farmers' rights	Seed certification	IPPC	Phytosanitary	UPOV (Latest Act)[3]	TRIPS - WTO	PBR[4]	PVP[5]	Cartagena Protocol on Biosafety	Biosafety regulations
Azerbaijan		P			X	P	X	1991		X		P	
Kazakhstan		P			X		X				X	P	X
Kyrgyz, Rep.		P			X	P	X	1991	P	X		P	O
Tajikistan		P			X		X			O	X	P	X
Turkmenistan		P			X						Regional	P	
Uzbekistan		P			X		X	1991		X			

[1] No information was available for Andorra, the Palestinian Authority, Puerto Rico and Somalia.

[2] Legislation on ABS also includes national approaches, policies, frameworks and guiding principles on ABS as well as regulations governing genebanks.

[3] Only the latest Act to which the country adhered is indicated. However the colour of the case does not refer to the date on which the country adhered to the latest Act but to the date on which the country joined UPOV (before or after 1996).

[4] Plant breeder's rights (PBR) legislation does comply with the UPOV Convention.

[5] Plant variety protection (PVP) legislation does not comply with the UPOVConvention.

APPENDIX 2

List of Major Germplasm Collections by Crop and Institute

LEGEND

Collections of germplasm accessions of major crops are grouped by main crop categories (cereals; food legumes; roots and tubers; vegetables; fruits; oil, sugar, forage, fibre, spice, stimulant and industrial crops). The collections are listed by institutes (indicated by an acronym and the WIEWS institution code) in descending order of the collection size. The percentage of accessions is the percentage of the genus total.

Accessions are categorized by type, expressed as a percentage of the institute's collection: wild species; landraces/old cultivars; advanced cultivars; breeding lines.

WS: wild species.

LR: landraces/old cultivars.

AC: advanced cultivars.

BL: research materials/breeding lines.

OT: (others) the type is unknown or a mixture of two or more types.

The information in this Annex is based on numbers of accessions, or samples, of germplasm.

Full names of the institutes mentioned in the following table are given in section Acronyms and Abbreviations at the end of this document.

Germplasm collections by crop

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Cereals										
Wheat	*Triticum*	MEX002	CIMMYT	110 281	13	6	31	50	7	6
Wheat	*Triticum*	USA029	NSGC	57 348	7	4	57	24	14	<1
Wheat	*Triticum*	CHN001	ICGR-CAAS	43 039	5	5				95
Wheat	*Triticum*	IND001	NBPGR	35 889	4	4	2	9	1	84
Wheat	*Triticum*	SYR002	ICARDA	34 951	4	5	75		<1	21
Wheat	*Triticum*	JPN003	NIAS	34 652	4	3	4	31		61
Wheat	*Triticum*	RUS001	VIR	34 253	4	1	43	20	35	<1
Wheat	*Triticum*	ITA004	IGV	32 751	4	2	98			
Wheat	*Triticum*	DEU146	IPK	26 842	3	4	49	12	32	4
Wheat	*Triticum*	AUS003	TAMAWC	23 811	3		3	50	32	16
Wheat	*Triticum*	IRN029	NPGBI-SPII	18 442	2					100
Wheat	*Triticum*	KAZ023	RIA	18 000	2					100
Wheat	*Triticum*	BRA015	CNPT	13 464	2					100
Wheat	*Triticum*	ETH085	IBC	13 421	2		100			<1
Wheat	*Triticum*	BGR001	IPGR	12 539	1	<1	9	7	2	82
Wheat	*Triticum*	POL003	IHAR	11 586	1		3	88	7	3
Wheat	*Triticum*	FRA040	INRA-CLERMON	10 715	1					100
Wheat	*Triticum*	CAN004	PGRC	10 514	1	19	14	35	28	3
Wheat	*Triticum*	CZE122	RICP	10 419	1	2	7	27	64	<1
Wheat	*Triticum*	GBR011	IPSR	9 462	1		11	28	25	36
Wheat	*Triticum*	CHL008	INIA QUIL	9 333	1					100
Wheat	*Triticum*	UZB006	UzRIPI	9 277	1					100
Wheat	*Triticum*	HUN003	RCA	8 569	1		2	<1	12	86
Wheat	*Triticum*	CYP004	ARI	7 696	1		1	99		
Wheat	*Triticum*	CHE001	RAC	7 266	1					100
Wheat	*Triticum*	UKR001	IR	7 220	1		4	42	53	1
Wheat	*Triticum*	PER002	UNALM	7 000	1					100
Wheat	*Triticum*		Others (206)	239 200	28	5	14	15	22	44
Wheat	***Triticum***		**Total**	**857 940**	**100**	**4**	**24**	**20**	**13**	**39**
Rice	*Oryza*	PHL001	IRRI	109 136	14	4	44	9	3	39
Rice	*Oryza*	IND001	NBPGR	86 119	11	1	18	<1	12	69
Rice	*Oryza*	CHN121	CNRRI	70 104	9	1	70	13	9	7
Rice	*Oryza*	JPN003	NIAS	44 489	6	<1	22	19		59
Rice	*Oryza*	KOR011	RDAGB-GRD	26 906	3	5	5	13	4	74
Rice	*Oryza*	USA970	DB NRRC	23 090	3	<1	5	93	2	
Rice	*Oryza*	CIV033	WARDA	21 527	3	1	47	51		1
Rice	*Oryza*	THA399	BRDO	20 000	3		100			
Rice	*Oryza*	LAO010	NARC	13 193	2		100			
Rice	*Oryza*	MYS117	SR, MARDI	11 596	1	1	99			
Rice	*Oryza*	BRA008	CNPAF	10 980	1					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Cereals										
Rice	*Oryza*	CIV005	IDESSA	9 675	1					100
Rice	*Oryza*	FRA014	CIRAD	7 306	1					100
Rice	*Oryza*	BGD002	BRRI	6 259	1	2	79	14		5
Rice	*Oryza*	VNM049	PRC	6 083	1					100
Rice	*Oryza*	IDN009	CRIA	5 917	1					100
Rice	*Oryza*	PHL158	PhilRice	5 000	1		100			
Rice	*Oryza*	PAK001	PGRI	4 949	1		100			
Rice	*Oryza*	PER017	INIA-EEA.POV	4 678	1				100	
Rice	*Oryza*		Others (160)	286 940	37	3	26	6	11	54
Rice	***Oryza***		**Total**	**773 947**	**100**	**2**	**35**	**11**	**7**	**45**
Barley	*Hordeum*	CAN004	PGRC	40 031	9	12	41	27	13	7
Barley	*Hordeum*	USA029	NSGC	29 874	6	7	56	23	15	
Barley	*Hordeum*	BRA003	CENARGEN	29 227	6					100
Barley	*Hordeum*	SYR002	ICARDA	26 679	6	7	67		<1	25
Barley	*Hordeum*	JPN003	NIAS	23 471	5	<1	6	15		79
Barley	*Hordeum*	DEU146	IPK	22 093	5	6	56	12	24	2
Barley	*Hordeum*	CHN001	ICGR-CAAS	18 617	4					100
Barley	*Hordeum*	KOR011	RDAGB-GRD	17 660	4		25	10	<1	64
Barley	*Hordeum*	RUS001	VIR	16 791	4		25			75
Barley	*Hordeum*	ETH085	IBC	16 388	3		94			6
Barley	*Hordeum*	MEX002	CIMMYT	15 473	3	<1	3	77	11	9
Barley	*Hordeum*	SWE054	NORDGEN	13 526	3	5	5	84	4	2
Barley	*Hordeum*	GBR011	IPSR	10 838	2		17	30	23	29
Barley	*Hordeum*	IND001	NBPGR	9 161	2	11	3	13	2	71
Barley	*Hordeum*	AUS091	SPB-UWA	9 031	2					100
Barley	*Hordeum*	IRN029	NPGBI-SPII	7 816	2					100
Barley	*Hordeum*	ISR003	ICCI-TELAVUN	6 658	1	100	<1			<1
Barley	*Hordeum*	POL003	IHAR	6 184	1		2	94	2	2
Barley	*Hordeum*	BGR001	IPGR	6 171	1	<1	<1	4	7	88
Barley	*Hordeum*		Others (185)	144 781	31	4	11	13	11	61
Barley	***Hordeum***		**Total**	**470 470**	**100**	**5**	**23**	**17**	**8**	**48**
Maize	*Zea*	MEX002	CIMMYT	26596	8	1	89	2	8	
Maize	*Zea*	PRT001	BPGV-DRAEDM	24529	7		8	91	1	
Maize	*Zea*	USA020	NC7	19988	6	2	79	17	2	1
Maize	*Zea*	CHN001	ICGR-CAAS	19088	6					100
Maize	*Zea*	MEX008	INIFAP	14067	4	1				99
Maize	*Zea*	RUS001	VIR	10483	3		31			69
Maize	*Zea*	IND001	NBPGR	6909	2	6	16	15	2	61
Maize	*Zea*	JPN003	NIAS	5935	2		7	4		88
Maize	*Zea*	SRB001	MRIZP	5475	2		55	45		

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Cereals										
Maize	*Zea*	COL029	CORPOICA	5234	2					100
Maize	*Zea*	ROM007	BRGV Suceava	4815	1		69	28	3	<1
Maize	*Zea*	BGR001	IPGR	4700	1		23	14	<1	63
Maize	*Zea*	FRA041	INRA-MONTPEL	4139	1		28	72		
Maize	*Zea*	BRA003	CENARGEN	4112	1					100
Maize	*Zea*	UKR001	IR	3974	1		13	83	5	<1
Maize	*Zea*	PER002	UNALM	3023	1		100			
Maize	*Zea*	VNM237	SSJC	2 914	1			100		
Maize	*Zea*	HUN003	RCA	2 765	1		38	8	3	51
Maize	*Zea*	ARG1346	BAP	2 584	1		100			
Maize	*Zea*	ESP004	INIACRF	2 344	1	<1	95	1		4
Maize	*Zea*	UZB006	UzRIPI	2 200	1					100
Maize	*Zea*	GRC001	CERI	2 048	1			85	14	<1
Maize	*Zea*	PHL130	IPB-UPLB	2 013	1	<1	100			
Maize	*Zea*	ECU021	EETP	2 000	1				100	
Maize	*Zea*		Others (257)	145 996	45	<1	29	17	5	49
Maize	***Zea***		**Total**	**327 931**	**100**	**1**	**33**	**21**	**4**	**42**
Sorghum	*Sorghum*	IND002	ICRISAT	37 904	16	1	86	13	<1	
Sorghum	*Sorghum*	USA016	S9	36 173	15	1	41	8	3	48
Sorghum	*Sorghum*	CHN001	ICGR-CAAS	18 263	8					100
Sorghum	*Sorghum*	IND001	NBPGR	17 466	7	15	73	1	1	10
Sorghum	*Sorghum*	ETH085	IBC	9 772	4		100			<1
Sorghum	*Sorghum*	BRA001	CNPMS	7 225	3					100
Sorghum	*Sorghum*	KEN015	KARI-NGBK	5 866	2	2	52	<1	1	44
Sorghum	*Sorghum*	JPN003	NIAS	5 074	2	<1	6	12		81
Sorghum	*Sorghum*	AUS048	ATCFC	4 487	2	8	2	70	6	15
Sorghum	*Sorghum*	MEX008	INIFAP	3 990	2					100
Sorghum	*Sorghum*	RUS001	VIR	3 963	2		16	3	1	81
Sorghum	*Sorghum*	FRA202	ORSTOM-MONTP	3 859	2	1			99	
Sorghum	*Sorghum*	ZMB030	SRGB	3 720	2	1	99			<1
Sorghum	*Sorghum*	ARG1342	BBC-INTA	3 249	1					100
Sorghum	*Sorghum*	SDN001	ARC	3 145	1					100
Sorghum	*Sorghum*	MLI070	URG	2 673	1		100			
Sorghum	*Sorghum*	UGA001	SAARI	2 635	1					100
Sorghum	*Sorghum*	VEN152	DANAC	2 068	1			100		
Sorghum	*Sorghum*	HND005	EAPZ	2 000	1					100
Sorghum	*Sorghum*		Others (153)	62 179	26	<1	14	10	11	63
Sorghum	***Sorghum***		**Total**	**235 711**	**100**	**2**	**38**	**9**	**5**	**47**
Oat	*Avena*	CAN004	PGRC	27 676	19	55	12	20	12	1
Oat	*Avena*	USA029	NSGC	21 195	14	49	14	24	13	
Oat	*Avena*	RUS001	VIR	11 857	8	19	41	<1	1	39

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Cereals										
Oat	*Avena*	DEU146	IPK	4 799	3	15	33	9	38	4
Oat	*Avena*	KEN015	KARI-NGBK	4 197	3	<1				100
Oat	*Avena*	AUS003	TAMAWC	3 674	2			<1	<1	99
Oat	*Avena*	CHN001	ICGR-CAAS	3 357	2					100
Oat	*Avena*	GBR011	IPSR	2 598	2	<1	17	22	53	8
Oat	*Avena*	POL003	IHAR	2 328	2	<1	5	44	48	3
Oat	*Avena*	BGR001	IPGR	2 311	2	<1	1	6	2	91
Oat	*Avena*	MAR088	INRA CRRAS	2 133	1		<1			100
Oat	*Avena*	CZE047	KROME	2 011	1	<1	3	1	53	42
Oat	*Avena*	ISR003	ICCI-TELAVUN	1 604	1	100				
Oat	*Avena*	JPN003	NIAS	1 540	1		2	6		92
Oat	*Avena*	FRA010	INRA-RENNES	1 504	1					100
Oat	*Avena*	ESP004	INIACRF	1 318	1	<1	97		1	1
Oat	*Avena*	HUN003	RCA	1 301	1	<1	6		8	86
Oat	*Avena*	ARG1224	EEA INTA Bordenave	1 287	1			100		
Oat	*Avena*	PER002	UNALM	1 200	1					100
Oat	*Avena*	IND027	IGFRI	1 125	1					100
Oat	*Avena*		Others (107)	49 245	33	17	12	4	8	59
Oat	***Avena***		**Total**	**148 260**	**100**	**26**	**14**	**11**	**11**	**38**
Pearl millet	*Pennisetum*	IND002	ICRISAT	21 583	33	3	86	9	1	1
Pearl millet	*Pennisetum*	BRA001	CNPMS	7 225	11					100
Pearl millet	*Pennisetum*	IND064	NBPGR	5 772	9		100			
Pearl millet	*Pennisetum*	FRA202	ORSTOM-MONTP	4 405	7	8		10	82	
Pearl millet	*Pennisetum*	CAN004	PGRC	3 816	6	1	98	<1	<1	1
Pearl millet	*Pennisetum*	NER047	ICRISAT	2 817	4		100			
Pearl millet	*Pennisetum*	UGA001	SAARI	2 142	3					100
Pearl millet	*Pennisetum*	USA016	S9	2 063	3	1	28	3	1	68
Pearl millet	*Pennisetum*		Others (96)	15 624	24	10	57	3	1	29
Pearl millet	***Pennisetum***		**Total**	**65 447**	**100**	**4**	**62**	**4**	**6**	**24**
Millet	*Setaria*	CHN001	ICGR-CAAS	26 233	56					100
Millet	*Setaria*	IND001	NBPGR	4 392	9	<1	17		<1	82
Millet	*Setaria*	FRA202	ORSTOM-MONTP	3 500	8					100
Millet	*Setaria*	JPN003	NIAS	2 531	5	1	38	1		60
Millet	*Setaria*	IND002	ICRISAT	1 535	3	4	96			
Millet	*Setaria*	USA020	NC7	1 010	2	2	11	1	2	84
Millet	*Setaria*		Others (74)	7 405	16	8	51	1	2	38
Millet	***Setaria***		**Total**	**46 606**	**100**	**1**	**15**	**<1**	**<1**	**83**
Wheat	*Aegilops*	ISR003	ICCI-TELAVUN	9 146	22	100				<1
Wheat	*Aegilops*	SYR002	ICARDA	3 847	9	100				<1
Wheat	*Aegilops*	IRN029	NPGBI-SPII	2 653	6	99				1

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Cereals										
Wheat	*Aegilops*	JPN003	NIAS	2 433	6	5				95
Wheat	*Aegilops*	RUS001	VIR	2 248	5					100
Wheat	*Aegilops*	USA029	NSGC	2 207	5	100				
Wheat	*Aegilops*	ARM035	LPGPB	1 827	4	100		<1		
Wheat	*Aegilops*	DEU146	IPK	1 526	4	100				<1
Wheat	*Aegilops*	MEX002	CIMMYT	1 326	3	99		<1		<1
Wheat	*Aegilops*	CAN015	WRS	1 100	3	100				
Wheat	*Aegilops*	FRA010	INRA-RENNES	1 070	3					100
Wheat	*Aegilops*		Others (53)	12 643	30	81	3	2		14
Wheat	***Aegilops***		**Total**	**42 026**	**100**	**81**	**1**	**1**		**18**
Wheat	*x Triticosecale*	MEX002	CIMMYT	17 394	46	<1		97	3	<1
Wheat	*x Triticosecale*	RUS001	VIR	2 030	5					100
Wheat	*x Triticosecale*	USA029	NSGC	2 009	5		1	83	16	
Wheat	*x Triticosecale*	CAN091	SCRDC-AAFC	2 000	5					100
Wheat	*x Triticosecale*	UKR001	IR	1 748	5			86	13	1
Wheat	*x Triticosecale*	POL025	LUBLIN	1 748	5			63	33	3
Wheat	*x Triticosecale*	DEU146	IPK	1 577	4		2	81	17	<1
Wheat	*x Triticosecale*		Others (62)	8 933	24	4	<1	36	11	49
Wheat	***x Triticosecale***		**Total**	**37 439**	**100**	**1**	**<1**	**68**	**8**	**23**
Millet	*Eleusine*	IND001	NBPGR	9 522	27	<1	18	<1	1	80
Millet	*Eleusine*	IND002	ICRISAT	5 949	17	2	95	1	2	
Millet	*Eleusine*	KEN015	KARI-NGBK	2 931	8	3	61	1		35
Millet	*Eleusine*	ETH085	IBC	2 173	6	<1	100			<1
Millet	*Eleusine*	UGA001	SAARI	1 231	3					100
Millet	*Eleusine*	ZMB030	SRGB	1 040	3	<1	100			<1
Millet	*Eleusine*	NPL055	CPBBD	869	2		100			
Millet	*Eleusine*	USA016	S9	766	2		<1			100
Millet	*Eleusine*		Others (38)	10 901	31	1	71	<1	<1	28
Millet	***Eleusine***		**Total**	**35 382**	**100**	**1**	**59**	**<1**	**1**	**39**
Amaranth	*Amaranthus*	IND001	NBPGR	5 760	20	6	25		5	65
Amaranth	*Amaranthus*	USA020	NC7	3 341	12	11	22	4	4	59
Amaranth	*Amaranthus*	BRA003	CENARGEN	2 328	8					100
Amaranth	*Amaranthus*	PER027	UNSAAC/CICA	1 600	6		100			
Amaranth	*Amaranthus*	CHN001	ICGR-CAAS	1 459	5					100
Amaranth	*Amaranthus*		Others (106)	13 827	49	6	47	3	1	42
Amaranth	***Amaranthus***		**Total**	**28 315**	**100**	**5**	**36**	**2**	**2**	**54**
Rye	*Secale*	RUS001	VIR	2 928	14		34			66
Rye	*Secale*	DEU146	IPK	2 392	11	9	27	27	30	7
Rye	*Secale*	POL003	IHAR	2 266	11	<1	12	86		2

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Cereals										
Rye	*Secale*	USA029	NSGC	2 106	10	4	77	3	16	1
Rye	*Secale*	CAN004	PGRC	1 446	7	10	23	16	47	3
Rye	*Secale*	BGR001	IPGR	1 248	6	<1	3	61	<1	35
Rye	*Secale*		Others (89)	8 807	42	9	26	12	17	36
Rye	***Secale***		**Total**	**21 193**	**100**	**6**	**29**	**22**	**15**	**27**
Chenopodium	*Chenopodium*	BOL138	BNGGA-PROINPA	4 312	27	9	91			
Chenopodium	*Chenopodium*	PER014	INIA-EEA.ILL	1 396	9		18			82
Chenopodium	*Chenopodium*	DEU146	IPK	1 056	6	93	1		<1	6
Chenopodium	*Chenopodium*	ECU023	DENAREF	681	4	2	62	2	3	32
Chenopodium	*Chenopodium*	ARG1191	UBA-FA	500	3		100			
Chenopodium	*Chenopodium*	COL006	U.NACIONAL	300	2					100
Chenopodium	*Chenopodium*		Others (69)	8 019	49	6	49	<1	1	44
Chenopodium	***Chenopodium***		**Total**	**16 264**	**100**	**11**	**55**	**<1**	**1**	**32**
Tef	*Eragrostis*	ETH085	IBC	4 741	54		100			
Tef	*Eragrostis*	USA022	W6	1 302	15	44	15	<1	4	37
Tef	*Eragrostis*	KEN015	KARI-NGBK	1 051	12	5	<1			95
Tef	*Eragrostis*	JPN003	NIAS	327	4	8	2	1		89
Tef	*Eragrostis*	IND001	NBPGR	269	3	6				94
Tef	*Eragrostis*	MEX035	CIFAP-CAL	258	3					100
Tef	*Eragrostis*		Others (42)	872	10	60	13	1	1	24
Tef	***Eragrostis***		**Total**	**8 820**	**100**	**14**	**57**	**<1**	**1**	**28**
Food legumes										
Bean	*Phaseolus*	COL003	CIAT	35 891	14	6	85	2	7	
Bean	*Phaseolus*	USA022	W6	14 674	6	6	67	3	21	4
Bean	*Phaseolus*	BRA008	CNPAF	14 460	6					100
Bean	*Phaseolus*	MEX008	INIFAP	12 752	5	17				83
Bean	*Phaseolus*	DEU146	IPK	8 680	3	1	66	4	28	1
Bean	*Phaseolus*	CHN001	ICGR-CAAS	7 365	3					100
Bean	*Phaseolus*	RUS001	VIR	6 144	2		22	20	3	55
Bean	*Phaseolus*	MWI004	BCA	6 000	2		100			
Bean	*Phaseolus*	HUN003	RCA	4 350	2		70	<1	<1	30
Bean	*Phaseolus*	IDN002	LBN	3 846	1					100
Bean	*Phaseolus*	KEN015	KARI-NGBK	3 534	1	<1	34	3	35	28
Bean	*Phaseolus*	BGR001	IPGR	3 220	1		32		<1	68
Bean	*Phaseolus*	ECU023	DENAREF	3 102	1	2	6	17	<1	75
Bean	*Phaseolus*	RWA002	ISAR	3 075	1					100
Bean	*Phaseolus*	ESP004	INIACRF	3 038	1		98	<1	<1	1
Bean	*Phaseolus*		Others (232)	132 238	50	1	30	4	13	52
Bean	***Phaseolus***		**Total**	**262 369**	**100**	**2**	**39**	**4**	**10**	**45**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Food legumes										
Soybean	*Glycine*	CHN001	ICGR-CAAS	32 021	14	21				79
Soybean	*Glycine*	USA033	SOY	21 075	9	10	80	5	4	1
Soybean	*Glycine*	KOR011	RDAGB-GRD	17 644	8	<1	45	5	1	50
Soybean	*Glycine*	TWN001	AVRDC	15 314	7		<1		<1	100
Soybean	*Glycine*	BRA014	CNPSO	11 800	5					100
Soybean	*Glycine*	JPN003	NIAS	11 473	5	5	33	21		40
Soybean	*Glycine*	RUS001	VIR	6 439	3		9	40	41	11
Soybean	*Glycine*	IND016	AICRP-Soybean	4 022	2	<1				100
Soybean	*Glycine*	CIV005	IDESSA	3 727	2					100
Soybean	*Glycine*	TWN006	TARI	2 745	1					100
Soybean	*Glycine*	DEU146	IPK	2 661	1	1	23	53	23	
Soybean	*Glycine*	ZWE003	CBICAU	2 236	1					100
Soybean	*Glycine*	IDN182	ICRR	2 198	1	<1				100
Soybean	*Glycine*	AUS048	ATCFC	2 121	1	3	<1	38	52	6
Soybean	*Glycine*	NGA039	IITA	1 909	1		5	4	1	90
Soybean	*Glycine*	FRA060	AMFO	1 582	1					100
Soybean	*Glycine*	THA005	FCRI-DA	1 510	1			100		
Soybean	*Glycine*	MEX001	INIA-Iguala	1 500	1					100
Soybean	*Glycine*	PHL130	IPB-UPLB	1 381	1		100			
Soybean	*Glycine*	UKR001	IR	1 288	1	3	1	21	72	3
Soybean	*Glycine*	COL017	ICA/REGION 1	1 235	1		<1	64	13	22
Soybean	*Glycine*	SRB002	IFVCNS	1 200	1				100	
Soybean	*Glycine*	ROM002	ICCPT Fundul	1 024	<1			62	38	<1
Soybean	*Glycine*		Others (166)	81 842	36	7	11	4	27	51
Soybean	***Glycine***		**Total**	**229 947**	**100**	**6**	**17**	**7**	**13**	**56**
Groundnut	*Arachis*	IND002	ICRISAT	15 419	12	3	46	32	7	13
Groundnut	*Arachis*	IND001	NBPGR	13 144	10	7	15	1	5	72
Groundnut	*Arachis*	USA016	S9	9 964	8	2	19	15	3	61
Groundnut	*Arachis*	ARG1342	BBC-INTA	8 347	6	4				96
Groundnut	*Arachis*	NER047	ICRISAT	7 262	6		100			
Groundnut	*Arachis*	CHN001	ICGR-CAAS	6 565	5					100
Groundnut	*Arachis*	BRA214	CENARGEN	2 042	2					100
Groundnut	*Arachis*	THA005	FCRI-DA	2 030	2			100		
Groundnut	*Arachis*	IDN179	ICABIOGRAD	1 730	1					100
Groundnut	*Arachis*	RUS001	VIR	1 667	1		41	40	19	
Groundnut	*Arachis*	ZMB014	MRS	1 500	1					100
Groundnut	*Arachis*	UZB006	UzRIPI	1 438	1					100
Groundnut	*Arachis*	PHL130	IPB-UPLB	1 272	1		100			
Groundnut	*Arachis*	AUS048	ATCFC	1 196	1	5	14	61	11	8
Groundnut	*Arachis*	JPN003	NIAS	1 181	1	1	22	13		64

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Food legumes										
Groundnut	*Arachis*	BOL160	CIFP	1 040	1	2	98			
Groundnut	*Arachis*		Others (130)	52 664	41	3	34	6	6	51
Groundnut	***Arachis***		**Total**	**128 461**	**100**	**3**	**31**	**10**	**4**	**52**
Chickpea	*Cicer*	IND002	ICRISAT	20 140	20	1	91	6	<1	1
Chickpea	*Cicer*	IND001	NBPGR	14 704	15	2	13	<1	13	72
Chickpea	*Cicer*	SYR002	ICARDA	13 219	13	2	52		<1	46
Chickpea	*Cicer*	AUS039	ATFCC	8 655	9	3	28	38	30	2
Chickpea	*Cicer*	USA022	W6	6 195	6	3	91	1	5	<1
Chickpea	*Cicer*	IRN029	NPGBI-SPII	5 700	6					100
Chickpea	*Cicer*	PAK001	PGRI	2 146	2	1	99			
Chickpea	*Cicer*	RUS001	VIR	2 091	2		5			95
Chickpea	*Cicer*	TUR001	AARI	2 075	2	1	99		<1	
Chickpea	*Cicer*	MEX001	INIA-Iguala	1 600	2					100
Chickpea	*Cicer*	ETH085	IBC	1 173	1		99			1
Chickpea	*Cicer*	HUN003	RCA	1 170	1	<1	2	14		83
Chickpea	*Cicer*	UZB006	UzRIPI	1 055	1					100
Chickpea	*Cicer*	UKR001	IR	1 021	1		16	73	11	<1
Chickpea	*Cicer*		Others (104)	17 369	18	1	50	7	4	38
Chickpea	***Cicer***		**Total**	**98 313**	**100**	**1**	**50**	**7**	**6**	**36**
Pea	*Pisum*	AUS039	ATFCC	7 230	8	1	36	20	13	31
Pea	*Pisum*	RUS001	VIR	6 653	7	<1	13	<1		87
Pea	*Pisum*	SYR002	ICARDA	6 129	7	4	27		<1	69
Pea	*Pisum*	DEU146	IPK	5 508	6	1	33	6	55	6
Pea	*Pisum*	USA022	W6	5 399	6	3	53	2	27	14
Pea	*Pisum*	ITA004	IGV	4 090	4					100
Pea	*Pisum*	CHN001	ICGR-CAAS	3 825	4					100
Pea	*Pisum*	GBR165	SASA	3 302	4	3	<1	5		92
Pea	*Pisum*	IND001	NBPGR	3 070	3	<1	9	<1	5	86
Pea	*Pisum*	POL033	SHRWIAT	2 960	3	<1				100
Pea	*Pisum*	SWE054	NORDGEN	2 798	3	2	16	54	15	13
Pea	*Pisum*	BRA012	CNPH	1 958	2					100
Pea	*Pisum*	ETH085	IBC	1 768	2		99			1
Pea	*Pisum*	UKR001	IR	1 671	2	<1	4	3	46	47
Pea	*Pisum*	BGR001	IPGR	1 589	2	<1	<1	17	3	79
Pea	*Pisum*	SRB002	IFVCNS	1 578	2				100	
Pea	*Pisum*	CZE090	SUMPERK	1 276	1	2	4	19	74	1
Pea	*Pisum*	HUN003	RCA	1 199	1		6	<1	3	90
Pea	*Pisum*	CHL004	INIA CARI	1 142	1		100			
Pea	*Pisum*	NLD037	CGN	1 001	1	2	34	9	50	5
Pea	*Pisum*	FRA065	INRA-VERSAIL	1 000	1					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Food legumes										
Pea	*Pisum*		Others (149)	28 831	31	3	14	12	20	51
Pea	***Pisum***		**Total**	**93 977**	**100**	**2**	**19**	**8**	**17**	**54**
Cowpea	*Vigna*	NGA039	IITA	15 588	24	4	64	8	<1	24
Cowpea	*Vigna*	USA016	S9	8 043	12	2	62	<1	<1	35
Cowpea	*Vigna*	BRA003	CENARGEN	5 501	8					100
Cowpea	*Vigna*	IDN002	LBN	3 930	6					100
Cowpea	*Vigna*	IND001	NBPGR	3 317	5	<1	9	<1	12	79
Cowpea	*Vigna*	CHN001	ICGR-CAAS	2 818	4					100
Cowpea	*Vigna*	JPN003	NIAS	2 431	4	<1	13	<1		86
Cowpea	*Vigna*	PHL130	IPB-UPLB	1 821	3		100			
Cowpea	*Vigna*	BWA002	DAR	1 435	2	<1	4			95
Cowpea	*Vigna*	RUS001	VIR	1 337	2		9			91
Cowpea	*Vigna*	TWN001	AVRDC	1 152	2		28		3	69
Cowpea	*Vigna*		Others (113)	17 860	27	7	46	5	3	39
Cowpea	***Vigna***		**Total**	**65 233**	**100**	**3**	**40**	**4**	**2**	**52**
Lentil	*Lens*	SYR002	ICARDA	10 864	19	5	41		<1	54
Lentil	*Lens*	IND001	NBPGR	9 989	17	<1	2	<1	1	97
Lentil	*Lens*	AUS039	ATFCC	5 251	9	4	54	10	5	26
Lentil	*Lens*	IRN029	NPGBI-SPII	3 011	5	11	52			37
Lentil	*Lens*	USA022	W6	2 874	5	5	79	1	6	10
Lentil	*Lens*	RUS001	VIR	2 375	4		70	<1	4	26
Lentil	*Lens*	CHL004	INIA CARI	1 345	2					100
Lentil	*Lens*	CAN004	PGRC	1 171	2	1	7	<1	3	88
Lentil	*Lens*	HUN003	RCA	1 074	2		3	1		96
Lentil	*Lens*	TUR001	AARI	1 073	2	1	98		1	
Lentil	*Lens*	ARM006	SCAPP	1 001	2			99	1	
Lentil	*Lens*		Others (94)	18 377	31	2	38	4	4	52
Lentil	***Lens***		**Total**	**58 405**	**100**	**3**	**36**	**4**	**3**	**55**
Faba bean	*Vicia*	SYR002	ICARDA	9 186	21		26		<1	74
Faba bean	*Vicia*	CHN001	ICGR-CAAS	4 207	10					100
Faba bean	*Vicia*	AUS039	ATFCC	2 565	6	<1	46	30	<1	24
Faba bean	*Vicia*	DEU146	IPK	1 921	4	<1	68	13	17	1
Faba bean	*Vicia*	FRA010	INRA-RENNES	1 700	4		59		41	
Faba bean	*Vicia*	ECU003	UC-ICN	1 650	4					100
Faba bean	*Vicia*	ITA004	IGV	1 420	3					100
Faba bean	*Vicia*	RUS001	VIR	1 259	3		2	3		95
Faba bean	*Vicia*	ESP004	INIACRF	1 252	3		91	2	5	2
Faba bean	*Vicia*	ETH085	IBC	1 143	3		100			

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Food legumes										
Faba bean	*Vicia*		Others (123)	17 417	40	2	34	15	12	38
Faba bean	***Vicia***		**Total**	**43 720**	**100**	**1**	**32**	**9**	**7**	**51**
Pigeon pea	*Cajanus*	IND002	ICRISAT	13 289	33	2	62	36	1	<1
Pigeon pea	*Cajanus*	IND001	NBPGR	12 859	32	4	30	2	4	60
Pigeon pea	*Cajanus*	KEN015	KARI-NGBK	1 288	3	<1	73	4	2	21
Pigeon pea	*Cajanus*	PHL130	IPB-UPLB	629	2		100			
Pigeon pea	*Cajanus*	AUS048	ATCFC	406	1	50	12	23	1	13
Pigeon pea	*Cajanus*		Others (85)	12 350	30	3	50	2	1	45
Pigeon pea	***Cajanus***		**Total**	**40 821**	**100**	**3**	**49**	**13**	**2**	**33**
Lupin	*Lupinus*	AUS002	WADA	3 880	10	52	19	21	8	<1
Lupin	*Lupinus*	DEU146	IPK	2 464	6	17	47	9	15	11
Lupin	*Lupinus*	RUS001	VIR	2 411	6		24	39	19	19
Lupin	*Lupinus*	FRA001	INRA-POITOU	2 046	5	13		85		2
Lupin	*Lupinus*	PER003	UNSAAC	1 940	5	7	93			
Lupin	*Lupinus*	ESP010	SIAEX	1 519	4	46	47	1	4	2
Lupin	*Lupinus*	GBR045	RNG	1 300	3					100
Lupin	*Lupinus*	USA022	W6	1 294	3	46	38	1	9	6
Lupin	*Lupinus*	CHL004	INIA CARI	1 259	3		100			
Lupin	*Lupinus*	POL033	SHRWIAT	1 049	3	48		17		35
Lupin	*Lupinus*		Others (98)	18 884	50	12	19	4	6	60
Lupin	***Lupinus***		**Total**	**38 046**	**100**	**18**	**27**	**12**	**6**	**36**
Bambara groundnut	*Vigna*	NGA039	IITA	2 031	33	<1	100			
Bambara groundnut	*Vigna*	FRA202	ORSTOM-MONTP	1 416	23		100			
Bambara groundnut	*Vigna*	BWA002	DAR	338	5		2			98
Bambara groundnut	*Vigna*	GHA087	PGRRI	310	5					100
Bambara groundnut	*Vigna*	TZA016	NPGRC	283	5	<1	81			18
Bambara groundnut	*Vigna*	ZMB030	SRGB	232	4		100			
Bambara groundnut	*Vigna*		Others (26)	1 539	25	1	62	6	1	29
Bambara groundnut	***Vigna***		**Total**	**6 149**	**100**	**<1**	**79**	**2**	**<1**	**19**
Bean	*Psophocarpus*	PNG005	DOA	455	11		45			55
Bean	*Psophocarpus*	MYS009	DGCB-UM	435	10					100
Bean	*Psophocarpus*	CZE075	TROPIC	413	10	<1		22	<1	77
Bean	*Psophocarpus*	LKA005	IDI	400	9	<1	100			
Bean	*Psophocarpus*	IDN002	LBN	380	9					100
Bean	*Psophocarpus*		Others (35)	2 148	51	3	41	1	12	44
Bean	***Psophocarpus***		**Total**	**4 231**	**100**	**2**	**35**	**3**	**6**	**55**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Roots and tubers										
Potato	*Solanum*	FRA179	INRA-RENNES	10 461	11	6	2	84	8	
Potato	*Solanum*	RUS001	VIR	8 889	9		46	3	26	25
Potato	*Solanum*	PER001	CIP	7 450	8	2	69	2	<1	27
Potato	*Solanum*	DEU159	IPK	5 392	5	18	37	7	32	6
Potato	*Solanum*	USA004	NR6	5 277	5	65	21	9	5	<1
Potato	*Solanum*	JPN003	NIAS	3 408	3	3	1	31		65
Potato	*Solanum*	COL029	CORPOICA	3 043	3					100
Potato	*Solanum*	IND029	CPRI	2 710	3	15		85		
Potato	*Solanum*	BOL064	BNGTRA-PROINPA	2 393	2	26	74			
Potato	*Solanum*	CZE027	HBROD	2 207	2	5	1	29	52	13
Potato	*Solanum*	ARG1347	BAL	1 739	2	85	15			
Potato	*Solanum*	BRA012	CNPH	1 735	2					100
Potato	*Solanum*	GBR165	SASA	1 671	2					100
Potato	*Solanum*	NLD028	ROPTA	1 610	2	3	1		1	95
Potato	*Solanum*	MEX116	PNP-INIFAP	1 500	2					100
Potato	*Solanum*	TWN006	TARI	1 282	1					100
Potato	*Solanum*	UZB033	SamAI	1 223	1					100
Potato	*Solanum*	POL002	IPRBON	1 182	1			8	92	
Potato	*Solanum*	KAZ004	RIPV	1 117	1	26	2	15	57	
Potato	*Solanum*	SVK006	SVKLOMNICA	1 080	1	1	2	47	41	9
Potato	*Solanum*		Others (157)	33 884	34	18	15	3	17	47
Potato	***Solanum***		**Total**	**99 253**	**100**	**15**	**20**	**16**	**14**	**35**
Sweet potato	*Ipomoea*	PER001	CIP	6 417	18	23	77		<1	
Sweet potato	*Ipomoea*	JPN003	NIAS	5 736	16	1	2	4		93
Sweet potato	*Ipomoea*	USA016	S9	1 208	3	16	13	9	32	31
Sweet potato	*Ipomoea*	PNG039	MHRP	1 161	3					100
Sweet potato	*Ipomoea*	BRA012	CNPH	1 043	3					100
Sweet potato	*Ipomoea*	CHN146	BAAFS	800	2					100
Sweet potato	*Ipomoea*	TWN006	TARI	757	2					100
Sweet potato	*Ipomoea*	PER055	FF.CC.AA.	750	2	100				
Sweet potato	*Ipomoea*	ARG1342	BBC-INTA	567	2	36	56	1	6	
Sweet potato	*Ipomoea*	VNM049	PRC	532	1		100			
Sweet potato	*Ipomoea*	MYS003	MARDI	528	1		100			
Sweet potato	*Ipomoea*		Others (146)	16 050	45	5	24	21	11	39
Sweet potato	***Ipomoea***		**Total**	**35 549**	**100**	**10**	**29**	**10**	**6**	**44**
Cassava	*Manihot*	COL003	CIAT	5 436	17	1	87	11		<1
Cassava	*Manihot*	BRA004	CNPMF	2 889	9					100
Cassava	*Manihot*	NGA039	IITA	2 756	8		28	47		25
Cassava	*Manihot*	IND007	ICAR	1 327	4					100
Cassava	*Manihot*	NGA002	NRCRI	1 174	4					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Roots and tubers										
Cassava	*Manihot*	UGA001	SAARI	1 136	4	<1	4	90	7	
Cassava	*Manihot*	MWI001	MARS	978	3		22	72	6	
Cassava	*Manihot*	IDN182	ICRR	954	3				100	
Cassava	*Manihot*	THA005	FCRI-DA	609	2			100		
Cassava	*Manihot*	BEN018	FAST	600	2		100			
Cassava	*Manihot*	GHA087	PGRRI	448	1					100
Cassava	*Manihot*	TGO035	ITRA	435	1		100			
Cassava	*Manihot*		Others (131)	13 708	42	6	26	3	14	50
Cassava	***Manihot***		**Total**	**32 450**	**100**	**3**	**32**	**15**	**9**	**41**
Yam	*Dioscorea*	NGA039	IITA	3 319	20	1	68	20		12
Yam	*Dioscorea*	CIV006	UNCI	1 538	9	25	75			
Yam	*Dioscorea*	BEN030	UAC	1 100	7	55	45			
Yam	*Dioscorea*	GHA087	PGRRI	1 040	6					100
Yam	*Dioscorea*	SLB001	DCRS	480	3		97	3	<1	
Yam	*Dioscorea*	LKA002	PU	474	3	1	99			
Yam	*Dioscorea*		Others (92)	8 495	52	8	50	<1	8	34
Yam	***Dioscorea***		**Total**	**16 446**	**100**	**10**	**55**	**4**	**4**	**26**
Taro	*Colocasia*	PNG006	WLMP	859	12					100
Taro	*Colocasia*	FJI049	RGC	850	12					100
Taro	*Colocasia*	MYS003	MARDI	622	9		100			
Taro	*Colocasia*	IND024	NBPGR	469	6		100			
Taro	*Colocasia*	THA056	HRI-DA/THA	453	6			100		
Taro	*Colocasia*	VNM049	PRC	393	5		100			
Taro	*Colocasia*	IDN002	LBN	350	5					100
Taro	*Colocasia*	USA037	UH	308	4					100
Taro	*Colocasia*	SLB001	DCRS	268	4	<1				100
Taro	*Colocasia*	JPN003	NIAS	250	3	<1	5			95
Taro	*Colocasia*	GHA087	PGRRI	200	3					100
Taro	*Colocasia*	AUS019	RSPAS	193	3	15			73	12
Taro	*Colocasia*		Others (58)	2 069	28	5	55	<1	17	23
Taro	***Colocasia***		**Total**	**7 284**	**100**	**2**	**36**	**6**	**7**	**49**
Vegetables										
Tomato	*Lycopersicon*	TWN001	AVRDC	7 548	9		1	3	1	96
Tomato	*Lycopersicon*	USA003	NE9	6 283	8	4	8	3	9	75
Tomato	*Lycopersicon*	PHL130	IPB-UPLB	4 751	6	9	86			5
Tomato	*Lycopersicon*	DEU146	IPK	4 062	5	3	40	22	33	1
Tomato	*Lycopersicon*	RUS001	VIR	2 540	3		19	1	79	1
Tomato	*Lycopersicon*	JPN003	NIAS	2 428	3	<1	1	5		93
Tomato	*Lycopersicon*	CAN004	PGRC	2 137	3	1	1	27	69	1
Tomato	*Lycopersicon*	COL004	ICA/REGION 5	2 018	2					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Vegetables										
Tomato	*Lycopersicon*	ESP026	BGUPV	1 927	2	9	69	<1	1	20
Tomato	*Lycopersicon*	IND001	NBPGR	1 796	2	4	10	22	8	56
Tomato	*Lycopersicon*	HUN003	RCA	1 749	2	1	16	<1	2	82
Tomato	*Lycopersicon*	BRA006	IAC	1 688	2					100
Tomato	*Lycopersicon*	KAZ004	RIPV	1 500	2	2	11	36	51	
Tomato	*Lycopersicon*	NLD037	CGN	1 306	2	8	7	13	55	17
Tomato	*Lycopersicon*	FRA215	GEVES	1 254	1				100	
Tomato	*Lycopersicon*	BGD186	EWS R&D	1 235	1					100
Tomato	*Lycopersicon*	CZE061	RICP	1 232	1	3	8	3	84	2
Tomato	*Lycopersicon*	BGR001	IPGR	1 128	1		10	11	3	76
Tomato	*Lycopersicon*	AUS048	ATCFC	1 074	1	9		6	74	12
Tomato	*Lycopersicon*	SRB002	IFVCNS	1 030	1				100	
Tomato	*Lycopersicon*	VNM006	FCRI	1 000	1		100			
Tomato	*Lycopersicon*		Others (142)	33 994	41	5	12	33	14	35
Tomato	***Lycopersicon***		**Total**	**83 680**	**100**	**4**	**17**	**18**	**19**	**42**
Capsicum	*Capsicum*	TWN001	AVRDC	7 860	11		3		3	94
Capsicum	*Capsicum*	USA016	S9	4 698	6	1	9	<1	16	74
Capsicum	*Capsicum*	MEX008	INIFAP	4 661	6				2	98
Capsicum	*Capsicum*	IND001	NBPGR	3 835	5	13	15	1	9	62
Capsicum	*Capsicum*	BRA006	IAC	2 321	3					100
Capsicum	*Capsicum*	JPN003	NIAS	2 271	3	1	2	2		95
Capsicum	*Capsicum*	PHL130	IPB-UPLB	1 880	3		84			16
Capsicum	*Capsicum*	TWN005	TSS-PDAF	1 800	2				100	
Capsicum	*Capsicum*	DEU146	IPK	1 526	2	1	66	4	28	2
Capsicum	*Capsicum*	CHN004	BVRC	1 394	2					100
Capsicum	*Capsicum*	FRA011	INRA-UGAFL	1 371	2	1			88	11
Capsicum	*Capsicum*	TUR001	AARI	1 334	2		99		1	
Capsicum	*Capsicum*	RUS001	VIR	1 273	2		6		53	41
Capsicum	*Capsicum*	CRI001	CATIE	1 163	2					100
Capsicum	*Capsicum*	PER002	UNALM	1 157	2		54			46
Capsicum	*Capsicum*	ESP026	BGUPV	1 074	1	1	88	<1	2	10
Capsicum	*Capsicum*	HUN001	VEGTBUD	1 069	1					100
Capsicum	*Capsicum*	SRB002	IFVCNS	1 055	1				100	
Capsicum	*Capsicum*	NLD037	CGN	1 009	1	5	22	2	50	21
Capsicum	*Capsicum*		Others (166)	30 783	42	3	21	4	13	59
Capsicum	***Capsicum***		**Total**	**73 534**	**100**	**2**	**19**	**2**	**15**	**62**
Cantaloupe	*Cucumis*	USA020	NC7	4 878	11	6	24	5	7	59
Cantaloupe	*Cucumis*	JPN003	NIAS	4 242	10	1	3	4		92
Cantaloupe	*Cucumis*	RUS001	VIR	2 998	7	1	3	33	4	59
Cantaloupe	*Cucumis*	CHN001	ICGR-CAAS	2 892	7					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Vegetables										
Cantaloupe	*Cucumis*	BRA012	CNPH	2 400	5					100
Cantaloupe	*Cucumis*	KAZ004	RIPV	2 377	5		1	95	3	
Cantaloupe	*Cucumis*	FRA215	GEVES	1 399	3				100	
Cantaloupe	*Cucumis*	DEU146	IPK	1 154	3	<1	38	3	53	6
Cantaloupe	*Cucumis*	IND001	NBPGR	1 070	2	29	44	1	17	8
Cantaloupe	*Cucumis*	IRN029	NPGBI-SPII	1 046	2		18			82
Cantaloupe	*Cucumis*	BGR001	IPGR	1 006	2		5	1	<1	94
Cantaloupe	*Cucumis*		Others (127)	18 827	43	2	28	12	9	49
Cantaloupe	***Cucumis***		**Total**	**44 289**	**100**	**3**	**18**	**13**	**10**	**56**
Cucurbita	*Cucurbita*	RUS001	VIR	5 771	15		53	25	12	10
Cucurbita	*Cucurbita*	CRI001	CATIE	2 612	7					100
Cucurbita	*Cucurbita*	BRA003	CENARGEN	1 897	5					100
Cucurbita	*Cucurbita*	CHN001	ICGR-CAAS	1 767	4					100
Cucurbita	*Cucurbita*	MEX008	INIFAP	1 580	4					100
Cucurbita	*Cucurbita*	JPN003	NIAS	1 295	3		2	1		96
Cucurbita	*Cucurbita*	USA016	S9	1 276	3	10	44	<1	3	42
Cucurbita	*Cucurbita*	DEU146	IPK	1 042	3		52	3	32	14
Cucurbita	*Cucurbita*		Others (144)	22 344	56	3	38	1	7	52
Cucurbita	***Cucurbita***		**Total**	**39 584**	**100**	**2**	**32**	**4**	**6**	**56**
Allium	*Allium*	IND1457	NRCOG	2 050	7		100			
Allium	*Allium*	RUS001	VIR	1 888	6		34		61	5
Allium	*Allium*	JPN003	NIAS	1 352	5	<1	2	5		94
Allium	*Allium*	USA003	NE9	1 304	4	<1	20	3	10	68
Allium	*Allium*	DEU146	IPK	1 264	4	8	58	8	22	4
Allium	*Allium*	GBR004	RBG	1 100	4	11			89	
Allium	*Allium*	TWN001	AVRDC	1 082	4		<1		7	93
Allium	*Allium*		Others (169)	19 914	66	6	25	6	16	47
Allium	***Allium***		**Total**	**29 954**	**100**	**5**	**29**	**4**	**19**	**43**
Rape	*Brassica*	CHN001	ICGR-CAAS	4 090	16					100
Rape	*Brassica*	IND001	NBPGR	2 585	10	<1	33		3	64
Rape	*Brassica*	BGD028	BINA	2 100	8					100
Rape	*Brassica*	JPN003	NIAS	1 579	6	<1	6	4		90
Rape	*Brassica*	AUS039	ATFCC	1 184	5	<1	6	1	3	90
Rape	*Brassica*	TWN001	AVRDC	1 091	4		10		69	21
Rape	*Brassica*	PAK001	PGRI	682	3		100			
Rape	*Brassica*	USA020	NC7	645	3	<1	6	2	1	90
Rape	*Brassica*	GBR006	HRIGRU	581	2	1	30		69	
Rape	*Brassica*	DEU146	IPK	493	2	<1	27	3	51	18

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Vegetables										
Rape	*Brassica*		Others (81)	10 527	41	1	31	1	7	59
Rape	***Brassica***		**Total**	**25 557**	**100**	**1**	**21**	**1**	**9**	**68**
Okra	*Abelmoschus*	CIV005	IDESSA	4 185	19					100
Okra	*Abelmoschus*	USA016	S9	2 969	13	<1	10		<1	89
Okra	*Abelmoschus*	IND001	NBPGR	2 651	12	16	30	<1	3	51
Okra	*Abelmoschus*	PHL130	IPB-UPLB	968	4	4	96			
Okra	*Abelmoschus*	FRA202	ORSTOM-MONTP	965	4	9			91	
Okra	*Abelmoschus*	GHA087	PGRRI	600	3					100
Okra	*Abelmoschus*	TUR001	AARI	563	3		98		2	
Okra	*Abelmoschus*		Others (87)	9 522	42	3	55	<1	4	38
Okra	***Abelmoschus***		**Total**	**22 423**	**100**	**4**	**35**	**<1**	**6**	**55**
Eggplant	*Solanum*	IND001	NBPGR	3 060	15	11	23	<1	5	61
Eggplant	*Solanum*	TWN001	AVRDC	3 003	14		17	<1	2	80
Eggplant	*Solanum*	JPN003	NIAS	1 223	6	<1	7	4		89
Eggplant	*Solanum*	USA016	S9	887	4	1	2		2	94
Eggplant	*Solanum*	BGD186	EWS R&D	826	4					100
Eggplant	*Solanum*	PHL130	IPB-UPLB	661	3	2	98			
Eggplant	*Solanum*	NLD037	CGN	639	3	27	47	2	14	10
Eggplant	*Solanum*		Others (123)	10 733	51	17	33	8	7	36
Eggplant	***Solanum***		**Total**	**21 032**	**100**	**11**	**27**	**4**	**5**	**52**
Oleracea	*Brassica*	GBR165	SASA	2 367	12		1			99
Oleracea	*Brassica*	USA003	NE9	1 625	8		6	1	5	88
Oleracea	*Brassica*	CHN004	BVRC	1 235	6					100
Oleracea	*Brassica*	DEU146	IPK	1 215	6	2	32	3	60	3
Oleracea	*Brassica*	FRA215	GEVES	1 200	6				100	
Oleracea	*Brassica*	RUS001	VIR	980	5		26		74	<1
Oleracea	*Brassica*	JPN003	NIAS	672	3		1	7		91
Oleracea	*Brassica*	NLD037	CGN	631	3	<1	12	2	75	11
Oleracea	*Brassica*		Others (98)	10 256	51	3	24	5	34	35
Oleracea	***Brassica***		**Total**	**20 181**	**100**	**1**	**16**	**3**	**33**	**46**
Melon	*Citrullus*	RUS001	VIR	2 412	16	1	40	54	2	3
Melon	*Citrullus*	USA016	S9	1 841	12	5	26	<1	5	64
Melon	*Citrullus*	CHN001	ICGR-CAAS	1 197	8					100
Melon	*Citrullus*	ISR002	IGB	840	6					100
Melon	*Citrullus*	UZB006	UzRIPI	805	5					100
Melon	*Citrullus*	BRA017	CPATSA	753	5					100
Melon	*Citrullus*	JPN003	NIAS	594	4	1	2	4		94
Melon	*Citrullus*	IRN029	NPGBI-SPII	570	4		65			35

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Vegetables										
Melon	*Citrullus*	KAZ004	RIPV	450	3		5	93	2	
Melon	*Citrullus*		Others (81)	5 682	38	9	37	3	13	39
Melon	***Citrullus***		**Total**	**15 144**	**100**	**4**	**26**	**13**	**6**	**51**
Carrot	*Daucus*	USA020	NC7	1 126	14	28	13	1	8	50
Carrot	*Daucus*	GBR006	HRIGRU	1 094	13	10	20	3	67	
Carrot	*Daucus*	RUS001	VIR	1 001	12	2	17			82
Carrot	*Daucus*	POL030	SKV	541	7	45	25	8	12	10
Carrot	*Daucus*	DEU146	IPK	488	6	35	16	1	48	1
Carrot	*Daucus*	CHN004	BVRC	407	5					100
Carrot	*Daucus*	FRA215	GEVES	384	5				100	
Carrot	*Daucus*	CZE061	RICP	366	4	6	1	1	89	4
Carrot	*Daucus*	JPN003	NIAS	342	4			4		96
Carrot	*Daucus*	UKR021	IOB	320	4		14	37	26	24
Carrot	*Daucus*		Others (67)	2 240	27	14	23	4	20	40
Carrot	***Daucus***		**Total**	**8 309**	**100**	**14**	**16**	**4**	**28**	**38**
Radish	*Raphanus*	JPN003	NIAS	877	11	<1	7	8		85
Radish	*Raphanus*	DEU146	IPK	741	9	23	35	1	38	3
Radish	*Raphanus*	USA003	NE9	696	9	1	4		16	80
Radish	*Raphanus*	RUS001	VIR	626	8		8	92	<1	
Radish	*Raphanus*	IND001	NBPGR	458	6	4	7	2	15	72
Radish	*Raphanus*	GBR165	SASA	453	6					100
Radish	*Raphanus*	NLD037	CGN	307	4		4	16	56	24
Radish	*Raphanus*		Others (85)	3 848	48	4	31	1	29	35
Radish	***Raphanus***		**Total**	**8 006**	**100**	**5**	**20**	**9**	**22**	**44**
Nuts, Fruits, Berries										
Prunus	*Prunus*	RUS001	VIR	6 579	9	18	13	2	24	44
Prunus	*Prunus*	USA276	UNMIHT	6 100	9			98		2
Prunus	*Prunus*	ITA378	CRA-FRU	2 421	3	<1	18	6	51	25
Prunus	*Prunus*	HUN021	EFOPP	2 259	3				5	95
Prunus	*Prunus*	TUR001	AARI	1 874	3	<1	81		19	
Prunus	*Prunus*	UKR046	KPS	1 458	2	1	11	1	41	46
Prunus	*Prunus*	CHE065	FRUCTUS	1 450	2		39			61
Prunus	*Prunus*	JPN003	NIAS	1 423	2	1	13	29		57
Prunus	*Prunus*	FRA057	INRA-BORDEAU	1 220	2	<1	<1		19	81
Prunus	*Prunus*	MEX008	INIFAP	1 116	2	3			97	<1
Prunus	*Prunus*	ROM009	ICPP Pitesti	1 093	2	2	30	37	29	1
Prunus	*Prunus*	IRN029	NPGBI-SPII	1 006	1					100
Prunus	*Prunus*	BRA020	CPACT/EMBRAP	1 006	1					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Nuts, Fruits, Berries										
Prunus	*Prunus*		Others (212)	40 517	58	4	10	10	38	38
Prunus	***Prunus***		**Total**	**69 522**	**100**	**4**	**12**	**16**	**30**	**38**
Apple	*Malus*	USA167	GEN	6 980	11	64	<1	9	1	26
Apple	*Malus*	RUS001	VIR	3 743	6	3	17	23	5	52
Apple	*Malus*	JPN003	NIAS	2 671	4	7	2	6		85
Apple	*Malus*	GBR030	NFC	2 223	4					100
Apple	*Malus*	CHE063	PSR	1 935	3					100
Apple	*Malus*	AUT024	KLOST	1 904	3					100
Apple	*Malus*	FRA028	INRA-ANGERS	1 895	3	10			90	
Apple	*Malus*	KAZ027	PG	1 719	3	3	<1		97	
Apple	*Malus*	BRA044	IAPAR	1 464	2					100
Apple	*Malus*	BEL019	CRAGXPP	1 175	2					100
Apple	*Malus*	CZE031	HOLOVOU	1 094	2	2	13	37	43	5
Apple	*Malus*	POL029	SKF	1 069	2	2		5	93	
Apple	*Malus*		Others (159)	32 970	54	2	18	4	32	44
Apple	***Malus***		**Total**	**60 842**	**100**	**9**	**11**	**6**	**26**	**48**
Grape	*Vitis*	FRA139	INRA/ENSA-M	5 158	9					100
Grape	*Vitis*	DEU098	JKI	3 657	6	4	22	44	28	2
Grape	*Vitis*	CHE019	RAC	3 254	5					100
Grape	*Vitis*	USA028	DAV	3 038	5	<1	<1	9	1	89
Grape	*Vitis*	UKR050	IVM	2 201	4	<1	57	24	8	10
Grape	*Vitis*	ITA388	CRA-VIT	2 106	4		1	37	60	2
Grape	*Vitis*	SVK018	SVKBRAT	1 900	3		<1	83	15	2
Grape	*Vitis*	UZB006	UzRIPI	1 580	3					100
Grape	*Vitis*	TUR001	AARI	1 437	2		100			
Grape	*Vitis*	BRA141	CNPUV	1 345	2					100
Grape	*Vitis*	ESP080	IMIACM	1 224	2					100
Grape	*Vitis*	ROM017	ICVV Valea C	1 187	2	1		5	95	
Grape	*Vitis*	HUN047	UHFI-RIVE	1 135	2					100
Grape	*Vitis*		Others (125)	30 384	51	3	12	6	26	53
Grape	***Vitis***		**Total**	**59 606**	**100**	**2**	**12**	**11**	**20**	**55**
Lemon	*Citrus*	BRA125	CCSM-IASP	2 134	7		5			95
Lemon	*Citrus*	JPN003	NIAS	2 118	7	<1	8	3		89
Lemon	*Citrus*	CHN020	CRI	1 880	6	1	31			68
Lemon	*Citrus*	USA129	NCGRCD	1 103	4	<1	1	1	71	27
Lemon	*Citrus*	FRA014	CIRAD	1 100	4					100
Lemon	*Citrus*	ZAF004	CSFRI	1 005	3					100
Lemon	*Citrus*		Others (144)	20 355	69	1	13	13	25	48
Lemon	***Citrus***		**Total**	**29 695**	**100**	**1**	**12**	**9**	**20**	**59**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Nuts, Fruits, Berries										
Mango	*Mangifera*	AUS088	Ayr DPI	18 606	73	<1		99	1	
Mango	*Mangifera*	IND045	CISH	726	3		100			
Mango	*Mangifera*	THA056	HRI-DA/THA	252	1			100		
Mango	*Mangifera*	USA047	MIA	240	1			1	48	51
Mango	*Mangifera*	IDN177	ILETRI	239	1				100	
Mango	*Mangifera*	SLE015	NUC	200	1				100	
Mango	*Mangifera*		Others (109)	5 390	21	<1	27	6	31	37
Mango	***Mangifera***		**Total**	**25 653**	**100**	**<1**	**8**	**74**	**10**	**8**
Pear	*Pyrus*	USA026	COR	2 232	9	11	5	34	48	2
Pear	*Pyrus*	RUS001	VIR	1 486	6		<1			100
Pear	*Pyrus*	CHE090	OSS Roggwil	1 240	5		1			99
Pear	*Pyrus*	FRA097	CBNA	914	4					100
Pear	*Pyrus*	BEL019	CRAGXPP	855	3					100
Pear	*Pyrus*	ITA378	CRA-FRU	761	3	2	29	12	30	27
Pear	*Pyrus*	JPN003	NIAS	744	3	14	11	7		68
Pear	*Pyrus*	UKR046	KPS	671	3	3	4	1	23	69
Pear	*Pyrus*	KAZ027	PG	607	2	100				
Pear	*Pyrus*	TUR001	AARI	553	2	<1	100			
Pear	*Pyrus*		Others (138)	14 730	59	2	20	4	29	45
Pear	***Pyrus***		**Total**	**24 793**	**100**	**5**	**16**	**6**	**23**	**50**
Strawberry	*Fragaria*	CAN004	PGRC	1 897	14	4			4	92
Strawberry	*Fragaria*	USA026	COR	1 822	13	34	3	35	28	<1
Strawberry	*Fragaria*	RUS001	VIR	940	7		7	2	69	23
Strawberry	*Fragaria*	JPN003	NIAS	912	7	2		10		88
Strawberry	*Fragaria*	DEU451	JKI	622	5					100
Strawberry	*Fragaria*	CHL008	INIA QUIL	500	4	100				
Strawberry	*Fragaria*	GBR012	GBREMR	329	2	10			85	5
Strawberry	*Fragaria*	ITA380	CRA-FRF	220	2		1	<1	99	
Strawberry	*Fragaria*	ROM009	ICPP Pitesti	201	1	5	<1	81	7	5
Strawberry	*Fragaria*		Others (69)	6 265	46	37	1	4	26	33
Strawberry	***Fragaria***		**Total**	**13 708**	**100**	**26**	**1**	**8**	**24**	**40**
Banana	*Musa*	BEL084	INIBAP	1 198	9	14	73			13
Banana	*Musa*	FRA014	CIRAD	520	4				4	96
Banana	*Musa*	HND003	DTRUFC	490	4	40		30	30	
Banana	*Musa*	BRA004	CNPMF	400	3					100
Banana	*Musa*	AUS035	QDPI	400	3					100
Banana	*Musa*	CMR052	CARBAP	385	3				100	
Banana	*Musa*	IND349	NRCB	364	3	2	95	3		
Banana	*Musa*	THA002	AD-KU	323	2	<1				100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Nuts, Fruits, Berries										
Banana	*Musa*	COL029	CORPOICA	310	2					100
Banana	*Musa*	UGA003	RRS-AD	309	2	<1			100	
Banana	*Musa*	COD003	INERA	300	2					100
Banana	*Musa*	NGA039	IITA	283	2					100
Banana	*Musa*	JAM003	BB	257	2			9	53	38
Banana	*Musa*	PHL019	SEABGRC-BPI	245	2					100
Banana	*Musa*	CRI011	CORBANA	240	2	100				
Banana	*Musa*	PNG004	DLP Laloki	230	2					100
Banana	*Musa*	MYS142	HRC, MARDI	217	2		100			
Banana	*Musa*		Others (115)	7 015	52	5	21	3	23	47
Banana	***Musa***		**Total**	**13 486**	**100**	**7**	**21**	**3**	**19**	**49**
Ribes	*Ribes*	USA026	COR	1 510	17	46	6	6	40	2
Ribes	*Ribes*	RUS001	VIR	888	10		1	4	63	32
Ribes	*Ribes*	GBR048	SCRI	860	10					100
Ribes	*Ribes*	NOR001	SFL	522	6	<1		96	4	
Ribes	*Ribes*	LTU010	BGVU	393	4	27		12	61	
Ribes	*Ribes*	FRA028	INRA-ANGERS	390	4					100
Ribes	*Ribes*	UKR029	LFS	356	4		9	1	70	20
Ribes	*Ribes*	CHE063	PSR	305	3					100
Ribes	*Ribes*		Others (51)	3 672	41	2	2	3	47	46
Ribes	***Ribes***		**Total**	**8 896**	**100**	**10**	**2**	**9**	**38**	**41**
Cashew	*Anacardium*	IND095	AICRP-Cashew	880	14					100
Cashew	*Anacardium*	THA022	PHES	744	12				100	
Cashew	*Anacardium*	BRA146	CNPAT	621	10					100
Cashew	*Anacardium*	NGA008	CRIN	574	9					100
Cashew	*Anacardium*	MOZ003	UDAC	530	8		100			
Cashew	*Anacardium*	COL029	CORPOICA	473	7					100
Cashew	*Anacardium*		Others (64)	2 556	40	<1	32	9	4	55
Cashew	***Anacardium***		**Total**	**6 378**	**100**	**<1**	**21**	**3**	**13**	**62**
Rose	*Rosa*	FRA217	GEVES	1 200	31					100
Rose	*Rosa*	JPN003	NIAS	634	17					100
Rose	*Rosa*	AZE017	CBG	250	7	60			40	
Rose	*Rosa*		Others (45)	1 732	45	18	8	8	24	41
Rose	***Rosa***		**Total**	**3 816**	**100**	**12**	**4**	**3**	**14**	**67**
Hazel	*Corylus*	USA026	COR	837	28	13	13	25	48	1
Hazel	*Corylus*	TUR001	AARI	413	14		100			
Hazel	*Corylus*	UKR046	KPS	188	6				1	99
Hazel	*Corylus*	AZE009	HSCRI	169	6		32	22	46	

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Nuts, Fruits, Berries										
Hazel	*Corylus*	ESP014	IRTAMB	120	4		6			94
Hazel	*Corylus*	UZB031	UzRIHVWM	118	4					100
Hazel	*Corylus*		Others (53)	1 153	38	3	9	13	37	39
Hazel	***Corylus***		**Total**	**2 998**	**100**	**5**	**23**	**13**	**30**	**29**
Peach palm	*Bactris*	CRI016	UCR-BIO	800	31					100
Peach palm	*Bactris*	BRA006	IAC	332	13					100
Peach palm	*Bactris*	COL029	CORPOICA	254	10					100
Peach palm	*Bactris*	ECU022	EENP	145	6		100			
Peach palm	*Bactris*	PAN002	INRENARE	65	3				100	
Peach palm	*Bactris*		Others (23)	997	38	7	2	<1	1	90
Peach palm	***Bactris***		**Total**	**2 593**	**100**	**3**	**6**	**<1**	**3**	**88**
Pistachio	*Pistacia*	IRN029	NPGBI-SPII	340	29					100
Pistachio	*Pistacia*	USA028	DAV	304	26	4	<1			96
Pistachio	*Pistacia*	ESP014	IRTAMB	106	9					100
Pistachio	*Pistacia*	AZE015	GRI	60	5		3	88	8	
Pistachio	*Pistacia*		Others (28)	358	31	33	4	3	28	31
Pistachio	***Pistacia***		**Total**	**1 168**	**100**	**11**	**2**	**6**	**9**	**73**
Sorbus	*Sorbus*	USA026	COR	282	37	32	44	13	6	6
Sorbus	*Sorbus*	GBR004	RBG	110	14	100				
Sorbus	*Sorbus*	AUT024	KLOST	71	9					100
Sorbus	*Sorbus*	UKR030	DFS	59	8					100
Sorbus	*Sorbus*	NLD145	NAKB	46	6				100	
Sorbus	*Sorbus*		Others (30)	195	26	18	15	7	11	48
Sorbus	***Sorbus***		**Total**	**763**	**100**	**31**	**20**	**7**	**11**	**31**
Oil crops										
Sesame	*Sesamum*	IND001	NBPGR	8 413	17	2	32	<1	26	39
Sesame	*Sesamum*	CHN001	ICGR-CAAS	4 726	9					100
Sesame	*Sesamum*	ISR001	REHOVOT	3 000	6					100
Sesame	*Sesamum*	KEN015	KARI-NGBK	2 477	5	1	3			96
Sesame	*Sesamum*	BRA003	CENARGEN	1 950	4					100
Sesame	*Sesamum*	JPN003	NIAS	1 789	4	<1	15	14		71
Sesame	*Sesamum*	MEX001	INIA-Iguala	1 600	3					100
Sesame	*Sesamum*	RUS001	VIR	1 504	3	<1	66	27	8	
Sesame	*Sesamum*	UZB006	UzRIPI	1 334	3					100
Sesame	*Sesamum*	USA016	S9	1 215	2	<1	14	1	12	72
Sesame	*Sesamum*	VEN132	INIA - CENIAP	1 024	2		100			
Sesame	*Sesamum*		Others (69)	21 431	42	1	55	5	1	38
Sesame	***Sesamum***		**Total**	**50 463**	**100**	**1**	**34**	**4**	**5**	**57**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Oil crops										
Sunflower	*Helianthus*	SRB002	IFVCNS	5 330	14	6			94	
Sunflower	*Helianthus*	USA020	NC7	3 729	9	42	7	16	8	28
Sunflower	*Helianthus*	CHN001	ICGR-CAAS	2 646	7					100
Sunflower	*Helianthus*	FRA040	INRA-CLERMON	2 500	6		32	20	48	
Sunflower	*Helianthus*	BRA014	CNPSO	2 400	6					100
Sunflower	*Helianthus*	RUS001	VIR	1 701	4					100
Sunflower	*Helianthus*	AUS048	ATCFC	1 290	3	17	1	47	18	18
Sunflower	*Helianthus*	IND041	DOR	1 260	3		100			
Sunflower	*Helianthus*	MAR088	INRA CRRAS	1 223	3					100
Sunflower	*Helianthus*	POL003	IHAR	1 105	3		<1			100
Sunflower	*Helianthus*	HUN003	RCA	1 032	3	<1	30	<1	61	9
Sunflower	*Helianthus*		Others (82)	15 164	39	8	15	12	8	58
Sunflower	***Helianthus***		**Total**	**39 380**	**100**	**8**	**12**	**9**	**22**	**49**
Safflower	*Carthamus*	IND041	DOR	6 863	23		100			
Safflower	*Carthamus*	CHN001	ICGR-CAAS	2 499	8					100
Safflower	*Carthamus*	USA022	W6	2 453	8	17	52	8	9	13
Safflower	*Carthamus*	MEX001	INIA-Iguala	1 550	5					100
Safflower	*Carthamus*	IRN029	NPGBI-SPII	816	3					100
Safflower	*Carthamus*	BRA007	CNPA	800	3					100
Safflower	*Carthamus*		Others (54)	14 670	49	1	21	3	3	71
Safflower	***Carthamus***		**Total**	**29 651**	**100**	**2**	**38**	**2**	**2**	**55**
Palm	*Elaeis*	COD003	INERA	17 631	84	1		99	<1	
Palm	*Elaeis*	MYS104	MPOB	1467	7	100				
Palm	*Elaeis*	BRA027	CPAA	564	3					100
Palm	*Elaeis*	COL096	ICA/REGION 5	301	1				100	
Palm	*Elaeis*	IDN193	IOPRI	237	1		1	97		2
Palm	*Elaeis*	SLE015	NUC	200	1				100	
Palm	*Elaeis*	GHA019	OPRI	150	1		100			
Palm	*Elaeis*		Others (21)	551	3	1	17		41	40
Palm	***Elaeis***		**Total**	**21 101**	**100**	**8**	**1**	**84**	**4**	**4**
Castor seed	*Ricinus*	IND001	NBPGR	4 307	24	3	15	<1	<1	81
Castor seed	*Ricinus*	CHN001	ICGR-CAAS	2 111	12					100
Castor seed	*Ricinus*	BRA007	CNPA	1 000	6					100
Castor seed	*Ricinus*	RUS001	VIR	696	4	<1	5			95
Castor seed	*Ricinus*	USA995	NCGRP	669	4			<1	<1	100
Castor seed	*Ricinus*	ETH085	IBC	510	3	88	2			10
Castor seed	*Ricinus*		Others (52)	8 702	48	37	17	3	1	42
Castor seed	***Ricinus***		**Total**	**17 995**	**100**	**21**	**12**	**1**	**<1**	**65**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Oil crops										
Physic nut	*Jatropha*	MEX006	UACH	1 444	44	4	96			
Physic nut	*Jatropha*	IND001	NBPGR	1 260	39	68	17		1	14
Physic nut	*Jatropha*	BRA007	CNPA	143	4					100
Physic nut	*Jatropha*		Others (20)	417	13	64	3	<1		32
Physic nut	***Jatropha***		**Total**	**3 264**	**100**	**36**	**49**	**<1**	**<1**	**14**
Olive	*Olea*	ITA401	CRA-OLI	443	17		33		67	
Olive	*Olea*	ESP046	CIFACOR	309	12		63			37
Olive	*Olea*	IRN029	NPGBI-SPII	247	9		15			85
Olive	*Olea*	USA028	DAV	142	5					100
Olive	*Olea*	AZE009	HSCRI	136	5			81	19	
Olive	*Olea*	TUR001	AARI	130	5		100			
Olive	*Olea*		Others (46)	1 222	46	2	15	5	45	34
Olive	***Olea***		**Total**	**2 629**	**100**	**1**	**26**	**6**	**33**	**34**
Forage crops										
Legumes	*Various*	IND001	NBPGR	19 579	11	6	20	<1	13	61
Legumes	*Various*	COL003	CIAT	13 690	7	99	<1			1
Legumes	*Various*	CHN001	ICGR-CAAS	11 201	6					100
Legumes	*Various*	TWN001	AVRDC	10 207	6		2		<1	98
Legumes	*Various*	AUS048	ATCFC	8 951	5	29	6	9	2	54
Legumes	*Various*	USA016	S9	7 474	4	7	3	7	<1	82
Legumes	*Various*	PHL130	IPB-UPLB	7 445	4	<1	100			<1
Legumes	*Various*	ETH013	ILRI-Ethiopia	7 310	4	99			1	
Legumes	*Various*	JPN003	NIAS	6 040	3	6	18	1		75
Legumes	*Various*	KEN015	KARI-NGBK	4 473	2	8	19	3		71
Legumes	*Various*	SYR002	ICARDA	3 435	2	98	2			<1
Legumes	*Various*	NZL001	AGRESEARCH	3 104	2					100
Legumes	*Various*	GBR004	RBG	2 809	2	100				
Legumes	*Various*	MEX001	INIA-Iguala	2 300	1					100
Legumes	*Various*	THA005	FCRI-DA	2 250	1			100		
Legumes	*Various*		Others (302)	72 877	40	28	28	2	3	39
Legumes	***Various***		**Total**	**183 145**	**100**	**29**	**19**	**3**	**3**	**47**
Medicago	*Medicago*	AUS006	AMGRC	27 827	30	78	1	16	3	3
Medicago	*Medicago*	UZB036	UzRICBSP	10 043	11					100
Medicago	*Medicago*	SYR002	ICARDA	9 164	10	90	4			6
Medicago	*Medicago*	USA022	W6	7 845	8	54	18	4	11	13
Medicago	*Medicago*	MAR088	INRA CRRAS	3 373	4	18	<1			82
Medicago	*Medicago*	RUS001	VIR	2 909	3	13	33			53
Medicago	*Medicago*	FRA041	INRA-MONTPEL	2 479	3	7	8			85
Medicago	*Medicago*	IRN029	NPGBI-SPII	2 415	3		15			85

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Forage crops										
Medicago	*Medicago*	LBY001	ARC	1 927	2	100				<1
Medicago	*Medicago*	JPN003	NIAS	1 486	2		1	3		96
Medicago	*Medicago*	ITA363	PERUG	1 338	1	16	7	50	5	23
Medicago	*Medicago*	TUR001	AARI	1 006	1	100			<1	
Medicago	*Medicago*		Others (132)	20 865	23	21	10	7	20	42
Medicago	***Medicago***		**Total**	**92 677**	**100**	**46**	**6**	**7**	**6**	**34**
Clover	*Trifolium*	AUS137	WADA	11 326	15	99		<1	1	
Clover	*Trifolium*	NZL001	AGRESEARCH	6 607	9					100
Clover	*Trifolium*	SYR002	ICARDA	4 522	6	82	4			14
Clover	*Trifolium*	GBR016	IBERS-GRU	4 362	6	32	1	17	15	35
Clover	*Trifolium*	ESP010	SIAEX	4 031	5	88		1	1	10
Clover	*Trifolium*	USA022	W6	3 476	5	46	9	5	17	23
Clover	*Trifolium*	RUS001	VIR	2 965	4	33	28	4		35
Clover	*Trifolium*	ITA394	CRA-FLC	1 878	3	94	1	1	4	
Clover	*Trifolium*	IRN029	NPGBI-SPII	1 626	2		14			86
Clover	*Trifolium*	ETH013	ILRI-Ethiopia	1 529	2	95			5	
Clover	*Trifolium*	JPN003	NIAS	1 441	2	2	1	4		93
Clover	*Trifolium*	TUR001	AARI	1 055	1	100				
Clover	*Trifolium*	DEU146	IPK	1 052	1	62	<1	1	18	19
Clover	*Trifolium*		Others (125)	28 548	38	42	7	4	9	38
Clover	***Trifolium***		**Total**	**74 418**	**100**	**53**	**5**	**3**	**6**	**33**
Grasses	*Various*	JPN055	KNAES	5 614	10					100
Grasses	*Various*	NZL001	AGRESEARCH	5 063	9					100
Grasses	*Various*	USA022	W6	4 502	8	67	4	1	5	23
Grasses	*Various*	KEN015	KARI-NGBK	4 491	8	4	10	<1		86
Grasses	*Various*	ETH013	ILRI-Ethiopia	2 016	4	96			4	
Grasses	*Various*	AUS048	ATCFC	1 528	3	40	<1	<1	1	59
Grasses	*Various*	MEX008	INIFAP	1 509	3	2				98
Grasses	*Various*	GBR004	RBG	1 337	2	100				
Grasses	*Various*		Others (213)	28 964	53	33	3	5	3	55
Grasses	***Various***		**Total**	**55 024**	**100**	**30**	**3**	**3**	**2**	**61**
Vicia	*Vicia*	SYR002	ICARDA	6 108	16	52	11			38
Vicia	*Vicia*	RUS001	VIR	5 751	15		27	1		72
Vicia	*Vicia*	DEU146	IPK	3 254	8	4	39	25	11	21
Vicia	*Vicia*	AUS039	ATFCC	2 749	7	6	<1	<1	<1	94
Vicia	*Vicia*	ITA004	IGV	2 210	6					100
Vicia	*Vicia*	TUR001	AARI	1 985	5	41	58		<1	
Vicia	*Vicia*	USA022	W6	1 841	5	46	14	<1	5	35
Vicia	*Vicia*	GBR001	SOUTA	1 781	5	100				

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Forage crops										
Vicia	*Vicia*	ESP004	INIACRF	1 516	4	15	83		<1	2
Vicia	*Vicia*	BGR001	IPGR	1 399	4	17			<1	83
Vicia	*Vicia*		Others (101)	9 864	26	23	26	4	5	41
Vicia	***Vicia***		**Total**	**38 458**	**100**	**25**	**23**	**3**	**3**	**46**
Fescue	*Festuca*	POL003	IHAR	4 777	14		<1			100
Fescue	*Festuca*	JPN003	NIAS	4 258	12		4	3		93
Fescue	*Festuca*	USA022	W6	2 452	7	63	6	1	14	16
Fescue	*Festuca*	DEU271	IPK	2 180	6	62	<1	4	25	9
Fescue	*Festuca*	GBR016	IBERS-GRU	1 498	4	65	5	6	6	19
Fescue	*Festuca*	CAN041	LRS	1 195	3	100				
Fescue	*Festuca*		Others (99)	17 844	52	22	24	1	7	46
Fescue	***Festuca***		**Total**	**34 204**	**100**	**26**	**14**	**2**	**6**	**52**
Grasses	*Dactylis*	POL022	BYDG	6 010	19		97		1	2
Grasses	*Dactylis*	JPN019	NGRI	2 684	9					100
Grasses	*Dactylis*	DEU271	IPK	1 929	6	79	<1	4	14	2
Grasses	*Dactylis*	USA022	W6	1 588	5	58	8	4	8	22
Grasses	*Dactylis*	GBR016	IBERS-GRU	1 094	3	66	2	16	9	7
Grasses	*Dactylis*		Others (95)	18 236	58	49	4	1	4	41
Grasses	***Dactylis***		**Total**	**31 541**	**100**	**39**	**21**	**2**	**4**	**34**
Pea	*Lathyrus*	FRA092	LEM/IBEAS	3 627	14	9				91
Pea	*Lathyrus*	SYR002	ICARDA	3 225	12	45	12			43
Pea	*Lathyrus*	IND001	NBPGR	2 797	11	<1	2	<1	3	94
Pea	*Lathyrus*	BGD164	BARI	1 845	7		100			
Pea	*Lathyrus*	CHL004	INIA CARI	1 424	5	100				
Pea	*Lathyrus*	AUS039	ATFCC	1 366	5					100
Pea	*Lathyrus*	GBR001	SOUTA	1 185	5	100				
Pea	*Lathyrus*		Others (88)	10 596	41	20	29	1	1	49
Pea	***Lathyrus***		**Total**	**26 065**	**100**	**25**	**21**	**<1**	**1**	**53**
Grasses	*Lolium*	DEU271	IPK	3 408	13	61	<1	3	27	9
Grasses	*Lolium*	GBR016	IBERS-GRU	3 194	12	58	1	10	20	11
Grasses	*Lolium*	POL022	BYDG	2 152	8		96		2	3
Grasses	*Lolium*	JPN003	NIAS	1 896	7	3	1	13		84
Grasses	*Lolium*	NZL001	AGRESEARCH	1 841	7					100
Grasses	*Lolium*	USA022	W6	1 364	5	45	6	<1	26	23
Grasses	*Lolium*	FRA040	INRA-CLERMON	1 000	4	70				30
Grasses	*Lolium*		Others (94)	11 039	43	21	8	2	17	52
Grasses	***Lolium***		**Total**	**25 894**	**100**	**29**	**12**	**3**	**15**	**41**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Forage crops										
Millet	*Panicum*	JPN003	NIAS	5 758	33	2	<1	1		97
Millet	*Panicum*	KEN015	KARI-NGBK	2 328	13	1	<1			98
Millet	*Panicum*	USA016	S9	784	4	2	<1	2	2	93
Millet	*Panicum*	CIV010	CN	570	3					100
Millet	*Panicum*	COL003	CIAT	563	3	98				2
Millet	*Panicum*		Others (86)	7 631	43	16	2	7	1	74
Millet	***Panicum***		**Total**	**17 634**	**100**	**11**	**1**	**3**	**1**	**84**
Pencilflower	*Stylosanthes*	COL003	CIAT	4 276	40	99	<1			<1
Pencilflower	*Stylosanthes*	AUS048	ATCFC	1 849	17	7		1	<1	92
Pencilflower	*Stylosanthes*	BRA010	CNPGC	1 062	10					100
Pencilflower	*Stylosanthes*	KEN015	KARI-NGBK	1 056	10	3	90			8
Pencilflower	*Stylosanthes*	ETH013	ILRI-Ethiopia	994	9	98			2	
Pencilflower	*Stylosanthes*	USA016	S9	111	1			1	1	98
Pencilflower	*Stylosanthes*		Others (39)	1 400	13	7	6	2	1	84
Pencilflower	***Stylosanthes***		**Total**	**10 748**	**100**	**51**	**10**	**<1**	**<1**	**39**
Grasses	*Poa*	POL022	BYDG	2 329	23		96		3	1
Grasses	*Poa*	USA022	W6	1 716	17	82	2	1	10	5
Grasses	*Poa*	DEU271	IPK	1 122	11	60	<1	4	26	10
Grasses	*Poa*	SWE054	NORDGEN	593	6	81	4	2	10	2
Grasses	*Poa*	NZL001	AGRESEARCH	321	3					100
Grasses	*Poa*	JPN003	NIAS	271	3	17	2	44		37
Grasses	*Poa*		Others (64)	3 897	38	29	1	2	12	56
Grasses	***Poa***		**Total**	**10 249**	**100**	**36**	**23**	**3**	**10**	**28**
Grasses	*Phleum*	POL003	IHAR	2 549	27		<1			100
Grasses	*Phleum*	DEU271	IPK	1 093	12	73	2	2	18	6
Grasses	*Phleum*	SWE054	NORDGEN	744	8	67	21	1	8	3
Grasses	*Phleum*	USA022	W6	692	7	37	10	<1	16	36
Grasses	*Phleum*	JPN003	NIAS	222	2		12	7		81
Grasses	*Phleum*		Others (57)	4 100	44	15	61	2	11	11
Grasses	***Phleum***		**Total**	**9 400**	**100**	**23**	**30**	**1**	**9**	**37**
Trefoil	*Lotus*	AUS006	AMGRC	1 934	22	92	<1	4	5	<1
Trefoil	*Lotus*	NZL001	AGRESEARCH	1 157	13					100
Trefoil	*Lotus*	USA022	W6	929	11	56	3	4	12	24
Trefoil	*Lotus*	CAN017	DPS-MGU	600	7	83				17
Trefoil	*Lotus*	GBR016	IBERS-GRU	492	6	20	1	30	16	34
Trefoil	*Lotus*	POL003	IHAR	269	3		4			96
Trefoil	*Lotus*	CHL004	INIA CARI	260	3	100				
Trefoil	*Lotus*	ITA363	PERUG	246	3	63		7	12	17

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Forage crops										
Trefoil	*Lotus*		Others (82)	2 895	33	51	15	2	5	28
Trefoil	***Lotus***		**Total**	**8 782**	**100**	**54**	**6**	**4**	**5**	**31**
Grasses	*Bromus*	USA022	W6	1 203	15	68	5	1	9	17
Grasses	*Bromus*	NZL001	AGRESEARCH	840	11					100
Grasses	*Bromus*	CHL028	INIA INTIH	595	8	100				
Grasses	*Bromus*	ARG1227	EEA INTA Anguil	490	6	100				
Grasses	*Bromus*	KAZ019	SPCGF	364	5	21		79		
Grasses	*Bromus*	URY002	FAGRO	320	4	100				
Grasses	*Bromus*	DEU146	IPK	317	4	11	<1		2	87
Grasses	*Bromus*	CAN004	PGRC	293	4	77	10	2	10	2
Grasses	*Bromus*	AUS006	AMGRC	229	3	93		<1	4	3
Grasses	*Bromus*		Others (84)	3 168	41	49	1	2	3	44
Grasses	***Bromus***		**Total**	**7 819**	**100**	**55**	**2**	**5**	**3**	**35**
Rye	*Elymus*	USA022	W6	3 310	67	92	3	<1	1	3
Rye	*Elymus*	SWE054	NORDGEN	300	6	100				
Rye	*Elymus*	AUS006	AMGRC	179	4	92			6	2
Rye	*Elymus*	DEU146	IPK	125	3	6	1		2	90
Rye	*Elymus*	CHN001	ICGR-CAAS	117	2					100
Rye	*Elymus*	CZE122	RICP	110	2	98			2	
Rye	*Elymus*		Others (42)	790	16	66	<1	1	3	29
Rye	***Elymus***		**Total**	**4 931**	**100**	**84**	**2**	**<1**	**2**	**12**
Grasses	*Cenchrus*	KEN015	KARI-NGBK	1 138	30	1	2			96
Grasses	*Cenchrus*	GBR016	IBERS-GRU	469	12	74		1	3	23
Grasses	*Cenchrus*	AUS048	ATCFC	395	11	10			<1	90
Grasses	*Cenchrus*	ETH013	ILRI-Ethiopia	293	8	95			5	
Grasses	*Cenchrus*	BRA017	CPATSA	237	6					100
Grasses	*Cenchrus*	JPN003	NIAS	195	5	5	1			94
Grasses	*Cenchrus*		Others (45)	1 031	27	22	5	8	<1	66
Grasses	***Cenchrus***		**Total**	**3 758**	**100**	**24**	**2**	**2**	**1**	**71**
Grasses	*Andropogon*	USA995	NCGRP	1 071	61	1			1	99
Grasses	*Andropogon*	KEN015	KARI-NGBK	116	7	1				99
Grasses	*Andropogon*	ETH013	ILRI-Ethiopia	104	6	98			2	
Grasses	*Andropogon*	COL003	CIAT	93	5	100				
Grasses	*Andropogon*	CAN041	LRS	55	3	100				
Grasses	*Andropogon*	ARG1133	IBONE	50	3					100
Grasses	*Andropogon*		Others (42)	277	16	28	5	4	5	58
Grasses	***Andropogon***		**Total**	**1 766**	**100**	**19**	**1**	**1**	**1**	**78**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	Genus	Instcode	Acronym	No.	%	WS	LR	BL	AC	OT
Sugar crops										
Sugar cane	*Saccharum*	BRA189	CTC	5 000	12					100
Sugar cane	*Saccharum*	CUB041	INICA	3 619	9	2			98	
Sugar cane	*Saccharum*	BRB001	WICSBS	3 493	8					100
Sugar cane	*Saccharum*	JPN003	NIAS	2 916	7	8	1	27		64
Sugar cane	*Saccharum*	USA047	MIA	2 426	6	10	3	2	7	77
Sugar cane	*Saccharum*	GUY016	GSC	2 223	5				100	
Sugar cane	*Saccharum*	DOM010	CRC	1 965	5					100
Sugar cane	*Saccharum*	BGD015	BSRI	1 364	3	3	27	31		40
Sugar cane	*Saccharum*	PAK130	SRI	1 200	3			100		
Sugar cane	*Saccharum*	PHL251	SRA-LGAREC	1 161	3		1	22	77	
Sugar cane	*Saccharum*	THA005	FCRI-DA	1 093	3	59		41		
Sugar cane	*Saccharum*		Others (49)	14 668	36	1	10	4	27	58
Sugar cane	***Saccharum***		**Total**	**41 128**	**100**	**3**	**5**	**9**	**26**	**56**
Beet	*Beta*	USA022	W6	2 510	11	26	34	19	15	5
Beet	*Beta*	DEU146	IPK	2 209	10	48	17	8	24	3
Beet	*Beta*	SRB002	IFVCNS	2 140	10				100	
Beet	*Beta*	FRA043	INRA-DIJON	1 630	7	11	31	28	31	
Beet	*Beta*	CHN001	ICGR-CAAS	1 388	6					100
Beet	*Beta*	RUS001	VIR	1 354	6		1	50	46	3
Beet	*Beta*	JPN003	NIAS	1 339	6	2		21		77
Beet	*Beta*		Others (96)	9 822	44	12	7	10	10	61
Beet	***Beta***		**Total**	**22 392**	**100**	**14**	**11**	**14**	**23**	**39**
Fibre crops										
Cotton	*Gossypium*	UZB036	UzRICBSP	12 048	11					100
Cotton	*Gossypium*	USA049	COT	9 387	9	21	2	8	4	64
Cotton	*Gossypium*	IND512	CICR	9 000	9		100			
Cotton	*Gossypium*	CHN001	ICGR-CAAS	7 226	7	7				93
Cotton	*Gossypium*	RUS001	VIR	6 205	6		23	16	58	3
Cotton	*Gossypium*	FRA002	IRCT-CIRAD	4 116	4	12	38			50
Cotton	*Gossypium*	BRA003	CENARGEN	3 179	3					100
Cotton	*Gossypium*	PAK009	CCRI	1 830	2	2		98		
Cotton	*Gossypium*	VNM013	INCORD	1 400	1			100		
Cotton	*Gossypium*	AZE015	GRI	1 370	1			<1	100	
Cotton	*Gossypium*		Others (98)	49 019	47	5	6	7	5	78
Cotton	***Gossypium***		**Total**	**104 780**	**100**	**5**	**15**	**8**	**7**	**65**
Flax	*Linum*	RUS001	VIR	5 282	12		10	39	<1	50
Flax	*Linum*	ETH085	IBC	3 433	8		100			
Flax	*Linum*	CAN004	PGRC	3 418	8	2	6	12	11	69
Flax	*Linum*	CHN001	ICGR-CAAS	3 003	7					100

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Fibre crops										
Flax	*Linum*	USA020	NC7	2 994	7	3	1	<1	5	90
Flax	*Linum*	ROM002	ICCPT Fundul	2 880	7	3	2	44	51	
Flax	*Linum*	IND849	Linseed	2 730	6		100			
Flax	*Linum*	DEU146	IPK	2 323	5	2	39	15	40	3
Flax	*Linum*	ARG1342	BBC-INTA	2 226	5				100	
Flax	*Linum*	CZE090	SUMPERK	2 054	5		25	24	50	1
Flax	*Linum*	BGR001	IPGR	1 437	3	<1	3		<1	96
Flax	*Linum*	UKR015	ILK	1 063	2		14	3	74	10
Flax	*Linum*		Others (69)	10 157	24	1	25	19	23	32
Flax	***Linum***		**Total**	**43 000**	**100**	**1**	**26**	**15**	**22**	**36**
Jute	*Corchorus*	IND001	NBPGR	5 408	46	5	37	3	2	54
Jute	*Corchorus*	BGD001	BJRI	4 110	35	7				93
Jute	*Corchorus*	KEN015	KARI-NGBK	203	2	22	66			12
Jute	*Corchorus*	THA005	FCRI-DA	160	1			100		
Jute	*Corchorus*	RUS001	VIR	150	1		1			99
Jute	*Corchorus*	TWN001	AVRDC	143	1		26		1	73
Jute	*Corchorus*		Others (35)	1 534	13	28	36	10	1	24
Jute	***Corchorus***		**Total**	**11 708**	**100**	**9**	**23**	**4**	**1**	**63**
Medicinal, Aromatic Plants, Spices, Stimulants										
Coffee	*Coffea*	CIV011	IRCC/CIRAD	6 560	22	87			2	11
Coffee	*Coffea*	BRA006	IAC	4 152	14					100
Coffee	*Coffea*	FRA014	CIRAD	3 800	13				55	45
Coffee	*Coffea*	CRI134	CATIE	1 835	6					100
Coffee	*Coffea*	CUB035	ECICC	1 597	5	10	64	10	16	
Coffee	*Coffea*	ETH075	JARC	1 284	4				7	93
Coffee	*Coffea*	COL014	CENICAFE	1 119	4	4				96
Coffee	*Coffea*		Others (56)	9 460	32	6	19	4	10	60
Coffee	***Coffea***		**Total**	**29 807**	**100**	**22**	**10**	**2**	**12**	**55**
Mustard	*Sinapis*	IND001	NBPGR	5 509	21	1	23	<1	2	75
Mustard	*Sinapis*	CHN001	ICGR-CAAS	3 073	12					100
Mustard	*Sinapis*	AUS039	ATFCC	1 547	6	2	11	19	17	51
Mustard	*Sinapis*	RUS001	VIR	1 372	5		4	17	79	
Mustard	*Sinapis*	VNM006	FCRI	1 300	5		100			
Mustard	*Sinapis*		Others (79)	13 607	52	3	57	2	5	32
Mustard	***Sinapis***		**Total**	**26 408**	**100**	**2**	**40**	**3**	**8**	**47**
Tobacco	*Nicotiana*	CHN001	ICGR-CAAS	3 407	16					100
Tobacco	*Nicotiana*	IND115	CTRI	2 550	12	6				94
Tobacco	*Nicotiana*	USA074	TOB	2 108	10	6	6	6	26	55

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Medicinal, Aromatic Plants, Spices, Stimulants										
Tobacco	*Nicotiana*	ITA403	CRA-CAT	1 711	8	84			16	
Tobacco	*Nicotiana*	AUS048	ATCFC	948	4	42	3	43	10	1
Tobacco	*Nicotiana*	POL057	PULT	908	4					100
Tobacco	*Nicotiana*	CUB029	IIT	780	4	4	7	88	1	
Tobacco	*Nicotiana*	TUR001	AARI	638	3		94		6	
Tobacco	*Nicotiana*	UKR079	KST	612	3		13		9	77
Tobacco	*Nicotiana*		Others (60)	8 053	37	4	11	15	22	49
Tobacco	***Nicotiana***		**Total**	**21 715**	**100**	**11**	**8**	**11**	**13**	**57**
Cocoa	*Theobroma*	TTO005	CRU	2 325	19	44	1		55	
Cocoa	*Theobroma*	GHA005	CRIG	1 000	8			100		
Cocoa	*Theobroma*	BRA074	CEPEC	754	6					100
Cocoa	*Theobroma*	COL029	CORPOICA	746	6					100
Cocoa	*Theobroma*	CRI134	CATIE	710	6					100
Cocoa	*Theobroma*	FRA014	CIRAD	700	6				29	71
Cocoa	*Theobroma*	CIV059	IDEFOR-DCC	700	6					100
Cocoa	*Theobroma*	ECU021	EETP	645	5					100
Cocoa	*Theobroma*	SLE015	NUC	200	2				100	
Cocoa	*Theobroma*		Others (51)	4 593	37	<1	22	8	6	64
Cocoa	***Theobroma***		**Total**	**12 373**	**100**	**8**	**8**	**11**	**16**	**56**
Tea	*Camellia*	JPN003	NIAS	7 312	62	<1	<1	2		98
Tea	*Camellia*	VNM025	VINATRI	2 500	21		100			
Tea	*Camellia*	IND368	UPASI-TRI	567	5		100			
Tea	*Camellia*	LKA123	TRI	560	5			100		
Tea	*Camellia*	BGD012	BTRI	474	4	<1	76		<1	24
Tea	*Camellia*	ARG1222	EEA INTA Cerro Azul	189	2			100		
Tea	*Camellia*	AZE009	HSCRI	81	1			86	14	
Tea	*Camellia*		Others (10)	156	1	3	13	40		45
Tea	***Camellia***		**Total**	**11 839**	**100**	**<1**	**29**	**9**	**<1**	**62**
Opium	*Papaver*	TUR001	AARI	3 559	35	1	99			
Opium	*Papaver*	DEU146	IPK	1 154	11	4	59	3	21	14
Opium	*Papaver*	UKR008	UDS	1 081	11		3	28	1	68
Opium	*Papaver*	HUN003	RCA	967	10	<1	66		13	21
Opium	*Papaver*	IND001	NBPGR	823	8	1	<1	17	<1	81
Opium	*Papaver*	USA022	W6	338	3	79	4		1	16
Opium	*Papaver*	RUS001	VIR	267	3		61	1	32	5
Opium	*Papaver*	SVK001	SVKPIEST	262	3		49	28	23	1
Opium	*Papaver*	BGR001	IPGR	244	2		2		<1	98
Opium	*Papaver*		Others (38)	1 376	14	15	20	5	16	45
Opium	***Papaver***		**Total**	**10 071**	**100**	**6**	**54**	**6**	**7**	**27**

Crop		Genebank		Accessions		Type of accession (%)				
Grouping	**Genus**	**Instcode**	**Acronym**	**No.**	**%**	**WS**	**LR**	**BL**	**AC**	**OT**
Industrial plants										
Para rubber	*Hevea*	MYS111	MRB	60 000	81	100				
Para rubber	*Hevea*	IND031	RRII	4 772	6	95			5	
Para rubber	*Hevea*	CIV061	IDEFOR-DPL	2 330	3					100
Para rubber	*Hevea*	LBR004	FPC	1 215	2			99	1	
Para rubber	*Hevea*	BRA006	IAC	1 000	1					100
Para rubber	*Hevea*	VNM009	RRI	960	1					100
Para rubber	*Hevea*		Others (16)	3 379	5	3	<1		6	91
Para rubber	***Hevea***		**Total**	**73 656**	**100**	**88**	**<1**	**2**	**1**	**10**
Wood crops	*Various*	FRA219	INRA-BORDEAU	24 275	40					100
Wood crops	*Various*	NLD039	IBN-DLO	10 795	18	2	2		1	96
Wood crops	*Various*	BRA190	CNPF	4 000	7					100
Wood crops	*Various*	GBR004	RBG	1 080	2	100				
Wood crops	*Various*	COL102	CC	791	1					100
Wood crops	*Various*	ARG1342	BBC-INTA	777	1	21	21		12	46
Wood crops	*Various*	IRL007	COILLTE	612	1	37		63		
Wood crops	*Various*	USA131	NA	529	1	60	13		1	26
Wood crops	*Various*	HND030	CONSEFORH	485	1	68	<1		32	
Wood crops	*Various*	POL001	PAN	450	1					100
Wood crops	*Various*	LTU001	LIA	302	<1		3	35		63
Wood crops	*Various*	ESP022	INIAFOR	240	<1				83	17
Wood crops	*Various*	HUN044	UHFI-DFD	239	<1	10			57	32
Wood crops	*Various*		Others (94)	15 983	26	7	3	1	3	86
Wood crops	***Various***		**Total**	**60 558**	**100**	**6**	**1**	**1**	**2**	**90**
Ornamentals	*Various*	JPN003	NIAS	3 807	22		<1	1		99
Ornamentals	*Various*	FRA179	INRA-RENNES	1 650	9		3		97	
Ornamentals	*Various*	POL001	PAN	1 540	9					100
Ornamentals	*Various*	CZE079	PRUHON	1 288	7	1	1	<1	93	5
Ornamentals	*Various*	BRA203	IBOT	1 272	7					100
Ornamentals	*Various*		Others (75)	8 112	46	17	3	19	20	41
Ornamentals	***Various***		**Total**	**17 669**	**100**	**8**	**2**	**9**	**25**	**56**

DRAFT APPENDIX 3

The state of the art: methodologies and technologies for the identification, conservation, and use of PGRFA

A3.1 INTRODUCTION

The genetic diversity of a population is what enables that population to adapt to its environment through natural selection. When genetic diversity is low, the possible combinations of genes that can be tested against environmental challenges is reduced, decreasing the probability of successful individuals arising in the population. Thus a population in nature (or managed in a protected area) needs to have adequate genetic diversity to sustain its continued existence.

A parallel scenario takes place in crop improvement programs. Breeders tap and recombine genetic variability in their breeding populations to screen for desired traits or characteristics that will allow the crop to be successful in the target environment or against the targeted pest or pathogen. Breeders need access to adequate genetic diversity for success in breeding programs.

Underlying these scenarios, superficially conceptualized as ‘diversity is good’ in nature and in crop improvement programs, are many complicated issues. One is separating phenotypic diversity from genetic diversity. Others are where to find genetic diversity, how to maintain it, how to measure or monitor it, and how to use it most efficiently. Complicating the processes of both scenarios can be the basic biology of the species studied: its breeding system, whether it is annual or perennial or in between, whether it is diploid or polyploid, what are its ecological tolerances, or whether researchers know any of these things already. There are also nonbiological complications that can impact both scenarios: organizational, policy, legal, and economic issues and issues of scale from local/regional to national to global with respect to the collaborations, incentives, and efficiencies that facilitate conservation and use of genetic resources.

The objective of this appendix is to summarize primarily the status of scientific knowledge, practices, and technologies involved with genetic diversity that have arisen since the first SoW report which had a similar summary presented there as its Annex 1. The status of the nonbiological issues will be touched upon as they present either advances or challenges for conservation and utilization of genetic resources.

The first SoW report’s Annex 1 set out clearly and well the rationale for the importance of genetic diversity within conservation efforts and for users of conserved germplasm, the contrasts between qualitative and quantitative genetic variation and the different emphases placed on these by curators and users of genetic resources, the means and techniques for conservation, the various breeding strategies and their roles and challenges with respect to breeding goals, and finally, the legal and economic issues that can promote or deter conservation and use of genetic resources. This appendix will not repeat that information, but will focus on what is new or changed since Annex 1.[1]

A3.2 ADVANCES IN GENETIC KNOWLEDGE RELEVANT TO PGRFA CONSERVATION AND USE

The primary advances in the past 12 years can be collectively described as entering the age of genomics with ramifications that permeate science and society. Genetics is the study of single genes in isolation, while genomics is the study of all the genes in the genome and the interactions among them and their environments. Genomics has developed from the confluence of genetics, automated laboratory tools for generating DNA- and RNA-based data, and methods of information management. Advances in taxonomy and systematics that derive from genomic information have caused genepool boundaries to be redrawn, generated new collection targets for genebanks, and offered new possible gene sources. Genomic contributions to basic biology have led to better understanding of metabolic processes and their key components allowing researchers to refine the targets of genes for possible improvement. Genomic contributions to the understanding of adaptation and evolution have led to the ability to understand better the distinctions between neutral genetic diversity and adaptive genetic diversity, and the role different markers can play in identifying and using each, and the role each can play with respect to conservation and use of PGR. Another important change is from population genetics to population genomics. Now it is possible by sampling at a population level to identify specific loci under natural selection and thus of adaptive importance. At landscape levels, it becomes possible to track gene expression at multiple sites yielding possible new tools for monitoring environmental changes and species' responses to them.

One specific example of the striking contrast between what was considered possible in 1995 and what is possible now comes from Annex 1 of the first SoW report, where it was stated that the direct application of DNA sequencing was more useful in the identification of a gene or genes than for analyzing a complete genotype. The conclusion at the time was that there was only "a very limited possibility to sample many variants for PGRFA characterization". Today it is very feasible to characterize large numbers of accessions for polymorphism at thousands of DNA loci across the genome.

A3.3 ADVANCES IN BIOTECHNOLOGY RELEVANT TO PGRFA CONSERVATION AND USE

The first wave of plant genomics was the era of single-gene sequencing, RFLP markers, low-density dot-blot types of arrays (or northerns), and a one-gene, one-phenotype paradigm. All of these were in place at the time of the first Sow1 report. The second wave consisted of whole-genome sequencing, single nucleotide polymorphism (SNP) markers, and medium-density arrays with the continued goal of finding genes responsible for specific phenotypes. In the current third wave, comparative whole-genome sequencing from multiple related species is possible and that is merging with extremely high-density genotyping (involving resequencing of individuals). Whole-genome arrays for monitoring genome-wide transcription, alternative splicing, DNA binding, and epigenetic state. The one-gene, one-phenotype paradigm is giving way to a new philosophy of a dynamic genome responding globally to developmental programs and environmental signals.[2]

Speed, scale, and size are the parameters that are most impacted upward by technological advances. Speed or throughput has increased by orders of magnitude in many diverse activities: for example, numbers of samples per day from which DNA can be isolated; numbers of members of a mapping population able to assayed per run or per day; or numbers of sequencing reactions per unit of time. Scale of approach has increased: for example, the numbers of markers that can simultaneously be run against individual DNA samples; the numbers of progeny from mutation events or recombination events that can be screened for low probability responses; or the numbers of samples that can be handled simultaneously in labs with robotics. Size has increased for many activities and many measures (e.g., base pairs, coverage of genome, or numbers of markers per centiMorgan of a genetic map): examples include lengths of fragments in BAC libraries, numbers of base pairs able to be sequenced per reaction; lengths of contigs assembled, and size of genome able to be wholly sequenced.

Two important parameters have gotten smaller with technological advances: costs (equipment and supplies) and turn-around time for experiments and assays. Altogether, the net result from the increases in speed, scale, and size and decreases in cost and time is a new kind of bottleneck: massive amounts of data to be processed, analyzed, displayed, and interpreted.

Since 1995, the genomes of 180 organisms (animals, plants, fungi, and micro-organisms) have been sequenced.[3] The first plant genome fully sequenced was *Arabidopsis thaliana* in 2000. The second plant species sequenced was a crop species: the sequences of two different genotypes of rice (*Oryza sativa*) were (*O. sativa indica* in 2002 and *O. sativa japonica* in 2005). Since then, a species of poplar was fully sequenced (2006). Genome sequencing projects are underway for other plant species. In addition to full genome sequencing, large amounts of sequence data are available for several other species from sequencing of sizable fragments of their genomes (e.g., sequencing BAC libraries and assembling the overlapping sequence fragments into contiguous runs). Examples of crop species with good representation in these sequence databases are *Brassica rapa*, *Carica papaya*, *Gossypium hirsutum*, *Glycine max*, *Hordeum vulgare*, *Lotus japonica*, *Medicago truncatula*, *Sorghum bicolor*, *Solanum lycopersicum*, *Triticum aestivum*, *Vitis vinifera*, and *Zea mays*. Another source of sequence information is the collections of expressed sequence tags (ESTs) generated for many crops. Maize, wheat, rice, barley, soybean, and Arabidopsis have the largest collections of EST sequences for plants, each with 1 million or more.[4]

The emergence of new DNA sequencing technology has been driven by the publicly and privately funded research advances in human genomics. Lagging behind, but benefitting greatly from the human genomics progress, has been the application of these technologies to plant research in general, and, more specifically, to research relevant to crop improvement, plant evolution, and PGR conservation. Today there are three main competing sequencing systems, with more on the horizon, each generation of which offers greater capacity, throughput, and cost effectiveness.[5]

A3.4 ASSESSING AND ANALYZING GENETIC DIVERSITY

Today there are many tools for measuring 'genetic diversity'. Many were in use at the time of the first SoW report and are still valuable (pedigree analysis, controlled, replicated field experiments dissecting phenotype from genotype, qualitative traits typically resulting from germplasm characterization, quantitative traits, isozyme markers, RFLPs, RAPDs, SSRs, and AFLPs)[6]. With the advent of more widespread genome sequencing, EST generation, and high-throughput marker screening systems, SSRs and AFLPs have become easier to generate and thus more widely used. Ability to discover SNPs (single nucleotide polymorphisms) in all parts of genomes is a direct result of greater sequencing capacity. SSRs and more recently SNPs are suitable for genotype fingerprinting.

Fingerprinting individuals for SNPs dispersed throughout a genome or a particular section of interest has become a very powerful way to characterize collections: breeding genepools, genebank collections, and populations. The utility of this for crop improvement, in situ conservation, and genebank conservation depends on the relationship of this type of genetic diversity to that desired by breeders, manager, and curators.

Qualitative traits (such as many disease resistances and stress tolerances) and quantitative traits (such as yield, productivity, height) are typically the targets for improvement in plant breeding programs and for characterization in genebank collections. Obtaining this information for collections of individuals is laborious and costly, involving screening in the presence of pathogens and stresses in replicated field experiments with adequate sample sizes. The utility of molecular markers that could serve as proxies for this type of genetic diversity is obvious.

Genes are the targets of natural selection and artificial selection. Selection is a locus-specific force creating a pattern of variation involving few loci in specific regions of the genome. Variation in the traits governed by genes should be a measure of the adaptive genetic diversity or adaptive potential of a population or breeding genepool. Neutral genetic variation, occurring in sections of the genome not involved with coding for genes or in regulation of genes and hence, assumed not to be under natural selection pressure, is what can be measured by the many types of molecular markers. These patterns of genetic variation are genome wide. The molecular methods are fast and relatively cheap, so surveys of molecular marker variation are attractive as a means to evaluate genetic diversity across populations or genepools. An advance of the past decade is that the relationships between adaptive genetic diversity and neutral genetic diversity are becoming much clearer.

Unfortunately molecular markers are not usually indicative of the adaptive potential of populations, although they have been used inappropriately for this purpose with the assumption that neutral markers and quantitative variation are positively correlated.[7] There are uses of neutral molecular markers that are appropriately of value for conservation and use of genetic resources. When the patterns of genetic variation at many molecular markers randomly scattered throughout a genome can be measured, they can be very useful for providing a measure of processes within landscapes (such as gene flow, genetic drift, and migration or dispersal, which act on the entire genome) important for population biology, for monitoring progress in maintaining species in protected areas, or for testing the success of spatial connections between reserves.[8]

Given the ability to work with the raw genomic sequence, the comprehensive pattern of DNA polymorphisms within a species can begin to be viewed. Arabidopsis has been plant most thoroughly studied at this level since it was sequenced. There is abundant natural variation for both neutral DNA markers and also for those loci that cause phenotypic changes.[9]

A3.5 APPLICATIONS OF BIOTECHNOLOGY

Conservation objectives have to be clearly understood in terms of the type of measure of genetic diversity will be used to carry them out. For example, assume an objective is to assay a number of populations of a species for diversity as measured by a neutral molecular marker and then to give conservation priority to the most diverse populations with the assumption that this will also conserve the greatest adaptive genetic diversity. Relatively few populations might be needed to capture the greatest amount of the neutral genetic diversity, but if the others were abandoned, contrary to the real objective, significant amounts of adaptive genetic diversity, which is not distributed uniformly among all populations, would thus be lost.[10]

For a variety of reasons such as relative cost, ease of use (especially if PCR based), and possibly a lack of understanding of the difference between neutral and adaptive genetic diversity, patterns of neutral molecular markers are being used as measures of 'genetic diversity' for purposes of assessing genetic resources collections. However, before neutral molecular markers (especially if there are only a relative few with respect to the entire genome) are used to survey germplasm accessions for 'genetic or allelic diversity' with the goal of selecting subsets to represent the diversity of the species or to identify duplicates, great care should be taken to determine if there is a positive correlation between the patterns of diversity revealed by these markers and the type of adaptive diversity for which the collection is being maintained. Unless the number of markers is large and distributed throughout the genome and the appropriate analysis is undertaken to highlight the pattern of variation in the genome that is likely to be a result of selective forces, it is not likely that the goal of identifying and conserving the most important accessions for maintaining adaptive genetic diversity will be met and valuable germplasm would be left out.

A3.6 CONSERVATION TECHNOLOGIES

One area that hasn't seen much change in technology is in orthodox seed-storage conditions. Current recommendations for temperature and humidity are still the same as those developed before the first SoW report. Since then, however, the country reports that are part of this second SoW report and the Global Crop Diversity Trust's crop-specific conservation strategies call attention to the concerns for backlogs in accession testing and regeneration. Where there is testing, need for regeneration after a shorter period of storage that anticipated is often found. It is possible, that as one researcher has found, humidity is the more critical of the two storage concerns, and that commonly used seed packaging materials are allowing seeds to experience higher humidity than is optimal with resulting loss of viability. Given the money and resources that less frequent regeneration would save, it is probably time to apply the innovation of the genomics age to the mundane concern of seed storage containers and temperature/humidity regimes.[11]

A3.7 BREEDING METHODOLOGIES

The advent of genomic tools has not reduced the importance of phenotypic characterization of breeding materials, mapping populations and natural populations, or genebank accessions. In fact, thorough and accurate phenotyping is more important than ever. Dissecting phenotypes into components can improve heritability and aid our understanding of the metabolic and physiological processes causing the phenotype.

Marker-assisted selection (MAS) was made possible by high throughput means of identifying and manipulating molecular markers on a large scale and by collaborations that made phenotyping and trait characterizations possible across several environments. Firm verifications of the co-segregation or identity of the trait of interest with one of the many possible types of DNA markers allows that marker to stand for the trait in manipulations of gene transfer and deployment of the trait in differing genetic backgrounds adapted to the environments critical to many breeding programs. MAS is becoming a valuable tool for many different crops.[12]

Association mapping, also known as linkage disequilibrium (LD) mapping or association analysis, is a population-based survey used to identify trait–marker relationships based on linkage disequilibrium. With the rapid advancement of genome projects generating a large amount of sequence information and SNP data, plant genomics has experienced a growing interest in an alternative approach for the identification of genes underlying quantitative traits. The new model is based on the possibility of investigating sequence variation directly in genes and not at anonymous linked markers. This approach exploits candidate gene sequence variation, and it relies on the existence of linkage disequilibrium (nonrandom association between alleles at linked loci) between detectable sequence polymorphism, SNPs, and quantitative trait nucleotides, which ultimately determines the patterns of phenotypic variation. From an operational point of view, the candidate gene approach has the advantage that once a major effect gene is determined and validated, MAS could then be practiced directly on the gene and, therefore, would not rely on the need for strong association (linkage disequilibrium) between the marker allele and the favorable allele of the gene of interest to be useful in other genetic backgrounds.

A3.8 BIOINFORMATICS

On the hardware side, one of the requisite advances for bioinformatics was the every increasing capacity for electronic data storage. Today it is measured in petabytes, about three orders of magnitude greater than what was commonly in use in 1995. Supercomputers (costly mainframe installations) were replaced for bioinformatics work at genome centers by computer server farms comprised of off-the-shelf, ordinary PCs or servers harnessed together to provide equal or greater computing capacity at lower cost and with built-in CPU redundancy for greater reliability even with individual unit failure.

Creative software engineering, open-source operating systems and database software, the advent of the ubiquitous access to and use of the internet, and public investment are the advances that have made possible the tools to manage genomics laboratories and to store, analyze, distribute, and interpret the massive datafiles created by the sequencers and marker analyses.

A3.9 LEGAL AND ECONOMIC TOOLS

The major international instrument impacting PGR conservation and use was the International Treaty for Plant Genetic Resources for Food and Agriculture.[13] This agreement obligates parties to the Treaty to develop legislation and regulations to fulfill its mandates to facilitate conservation, exchange, and use of the genetic resources covered by the Treaty.

National and international funding research bodies recognized the need for collaboration for successful genomics projects and tailored some of their funding programs to specifically underwrite collaborative efforts. The results have been public investments in sequencing centers, databases of genomic data, tools for analyses, and public access, typically via the internet.

A3.10 LOOKING AHEAD

The future will present multiple challenges to crop performance that can be met effectively by changing the crop environment through management, and by modifying the crop genomes through plant breeding and molecular biology. In order to increase the reliability of crop performance prediction based upon genetic information, new tools are needed to more effectively relate observed phenotypes to genotypes. The subtleties of phenotypic plasticity in the face of a changing environment and the layers of genetic redundancy that characterize biological systems remain largely mysterious. The remarkable success that has been achieved in modifying plants for agricultural use has been based largely on centuries of practices guided by phenotypic data, rather than on a genetic, biochemical, or molecular understanding.

Genomic progress to date has only provided the very beginning of understanding for the way in which a genotype confers a particular set of attributes to a living organism. Today, it is possible to dissect a complex phenotype and to determine where individual genes or, more correctly, quantitative trait loci (QTLs) are physically located along the chromosomes. Information about DNA markers linked to QTLs represents a powerful diagnostic tool that enables a breeder to select for specific introgressions of interest. As more genes of interest are cloned and their contributions to complex biological systems are better understood, there will be many opportunities for creative synthesis of new varieties. It is possible that some of the opportunities will involve genetic engineering approaches, where new information about genes, gene regulation, and plant responses to the environment may be used in innovative ways to fine-tune existing plant varieties so that they utilize resources more efficiently, provide greater nutritional value, or simply taste better.[14]

[1] **Fulton, T.M.** 2008. State of the art of methodologies, technologies, and capacities for crop improvement and base broadening. Thematic Study for the Second State of the World Report on PGRFA. UN Food and Agriculture Organization. Rome, Italy.
Lopes, M.A. 2008. The state of utilization of PGRFA—A contribution to the preparation of the 2nd Report of the SoW PGRFA. UN Food and Agriculture Organization. Rome, Italy.
These two background documents provide detailed discussion of the genomics methodologies and technologies that have been applied to conservation and use of PGR and have informed this summary appendix.

[2] The characterization of progress in genomic technology in this paragraph as a series of waves derives from this review: **Borevitz, J.O. and Ecker, J.R.** 2004. Plant genomics: The third wave. *Annu. Rev. Genom. Hum. Genet.* **5**:443-447.
While this survey of what has been and what will be possible for plant genomics is based on progress with *Arabidopsis thaliana*, there is much of relevance here to plant genomics in general.

[3] See the 'Quick Guide to Sequenced Genomes' maintained at the Genome News Network. http://www.genomenewsnetwork.org/resources/sequenced_genomes/genome_guide_p1.shtml.

[4] A good entry point to access sequence databases for plants is PlantGDB at http://www.plantgdb.org/.

[5] **Strausberg, R.L., Levy, S. and Rogers, Y.-H.** 2008. Emerging DNA sequencing technologies for human genomic medicine. *Drug Discovery Today* **13**:569-577.
Although presented in the context of human genomics, the three major sequencing technologies described are in use in crop plant research today and the forecast of emerging ones is equally relevant.

[6] All of these were described in Annex 1 of the first SoW report.

[7] Reference examples of differences among marker types.

[8] **Holderegger, R., Kamm, U. and Gugerli, F.** 2006. Adaptive vs. neutral genetic diversity: Implications for landscape genetics. *Landscape Ecology* **21**:797-807.

[9] **Borevitz, J.O. and Ecker, J.R.** 2004. Ibid. note 2.

[10] **Bonin, A., Nicole, F., Pompanon, F., Miaud, C. and Taberlet, P.** 2007. Population adaptive index: A new method to help measure intraspecific genetic diversity and prioritize populations for conservation. *Conservation Biology* **21**:697-708.
Combines an analysis of the differences among neutral and adaptive diversity with a presentation of a 'population adaptive index' proposed as a way to allow use of many molecular markers distributed throughout the genome (a measure only possible because of advances in biotechnology) that will allow pinpointing localized variations in the pattern of diversity thus detecting loci supposedly under natural selection and thus of adaptive significance.

[11] **Pérez-García, F., González-Benito, M.E. and Gómez-Campo, C.** 2007. High viability recorded in ultra-dry seeds of Brassicaceae after almost 40 years of storage. *Seed Science and Technology* **35**:143-153.
See this paper for results of a study of the impact of humidity and quality of storage materials on seed longevity.

[12] **Guimarães, E.P., Ruane, J., Scherf, B.D., Sonnino, A. and Dargie, J.D. (eds.)** 2007. *Marker-assisted selection: Current status and future perspectives in crops, livestock, forestry and fish*. UN Food and Agriculture Organization. Rome, Italy.

[13] See Chapter 7.

[14] **Lopes, M.A.** 2008. Ibid. note 1.

DRAFT APPENDIX 4

State of diversity of major and minor crops

A4.1 INTRODUCTION

In Annex 2 of the first SoW report, a number of crops of major and minor importance for food security in one or more global subregions were surveyed for the state of their diversity. Similarly here, major crops (wheat, rice, maize, sorghum, cassava, potato, sweet potato, beans (*Phaseolus*), soybean, sugar crops, and banana/plantain) and a number of globally minor , but subregionally or nationally major, crops (millets, roots and tubers other than the ones listed above, pulse crops other than species of *Phaseolus*, grapes, tree nuts, and vegetables and melons) are surveyed. While this range of crops is not a definitive list of staple or important food crops, it does include examples of different crop groups (cereals, food legumes, roots and tubers, tree crops), species with different breeding systems (cross-pollinating, self-pollinating, clonally propagated), and crops of temperate and tropical origin. It also includes crops for which there has been great investment in conservation and improvement, notably wheat, rice and maize, as well as crops for which there has been relatively less investment, such as cassava, sweet potato, and plantain. This list of major and minor crops also provides a good sampling of the crops listed in Annex 1 of the ITPGRFA.[1]

The purpose of this annex is not simply to repeat information presented in Chapters 1, 2, and 3 of the main report, but to highlight some of that information in a crop-oriented context. General information is provided here on the major patterns of production and area harvested of the major and minor crops over the years 1995 through 2007; the composition of their genepools; the state of in situ diversity for the crop species, if wild forms exist, and of CWRs and *in situ* conservation programs (more details are in Chapter 2); specific reports of genetic erosion; summaries of status of major *ex situ* collections (a more detailed assessment is provided in Chapter 3); the status of safety duplication of *ex situ* collections, gaps, opportunities, and priorities in the extent of coverage of the genepool diversity in *ex situ* collections; the extent of documentation, characterization, and evaluation of collections; issues related to utilization of collections; the impact of climate change on priorities and concerns for both *in situ* and *ex situ* conservation; and the role of specific crops for sustainable production systems, organic production systems, and farmer opportunities. In the individual crop sections that follow, specific concerns are highlighted.[2]

Diversity status

Since 1995, more than 1 million germplasm samples have been added to *ex situ* collections and at least a quarter of these accessions are the result of new collecting missions (from fields, markets, and nature)[3]. The remainder are probably a result of increased exchange of accessions among collections. Number of accessions is not a direct measure of diversity.

There are many germplasm descriptors from which the diversity status of a collection can be derived or inferred (for example, passport information, phenotype information for many characters, genotype information from many possible markers and assays, and basic taxon biology). The assessment of diversity thus depends upon the uniform availability of such information for the collections to be studied. As pointed out by many sources, uneven documentation of crop germplasm is a major shortcoming for most collections.

Even less is known about the state of diversity represented in genebank accessions of wild species related to crops or about the status of diversity in taxa growing in any sort of natural reserve or other *in situ* conservation situation. As pointed out in Chapter 2, very few (<50) wild species related to crops (crop wild relatives: CWRs) have been assessed for their diversity status compared to the hundreds of known CWRs. Many country reports have stressed concern for the lack of attention for both *in situ* and *ex situ* conservation of CWRs. Chapter 2 also reports on the CGRFA-commissioned study to identify conservation priorities and specific locations for critical *in situ* conservation of CWRs of the major food crops on almost all continents.[4]

Even as studies and reports have been identifying gaps and deficiencies and raising alarms, there has been progress in diversity assessments since the first SoW report, motivated by many factors, actors, and initiatives:

- increasing country compliance with mandates of the CBD and national biodiversity strategies and action plans;
- the coming into force of the ITPGRFA and steps taken by countries for its implementation;
- the FAO Commission on Genetic Resources for Food and Agriculture, the first SoW report, and the subsequent Global Plan of Action for Conservation and Sustainable Utilization of PGRFA;
- the international research organization IPBGR/IPGRI/Bioversity International and its efforts at research, documentation, and training dedicated to conservation of agrobiodiversity;
- the efforts of the international centers of the CGIAR with their various mandated crops;
- national and regional efforts (for example, USDA, USAID, Sida, European Commission) at training and capacity building for conservation and utilization in countries with priority crops;
- the establishment of the Global Crop Diversity Trust and its efforts to motivate assessments and conservation strategies and to provide funding to carry out the priorities thus established.

As reported in Chapter 2, since 1995 many countries have carried out specific surveys and inventories at least at the level of species, either as part of their National Biodiversity Strategy and Action Plans or within the framework of individual projects. Most have been limited to single crops, small groups of species, or limited areas within the national territory. The CGIAR center ICARDA has assisted countries in North Africa, the Near East, and Central Asia in surveys to assess density, frequency, and threats to relatives of wild species. Academic research undertakings have surveyed active farms in several different countries to assess the extent of traditional varieties still grown in spite of availability of modern, high-yielding varieties of many crops and report that a significant amount of crop genetic diversity in the form of traditional varieties continues to be maintained on farm (see Chapter 2 and country reports from Bosnia Herzegovina, Iceland, the Former Yugoslav Republic of Macedonia, Niger, Poland, and Switzerland which affirm that crop diversity is still high and that special efforts are made to keep it that way). For example, in Niger, no genetic erosion was observed during recent collecting missions and many traditional cultivars still prevailed in farmers' fields. No losses of millets and sorghum varieties could be detected in comparing collecting missions of 1973 and 2003, however, improved varieties of millet had increased.

On the other hand, there continue to be recurring reports and alerts about the dwindling diversity of landraces and traditional varieties in production and in conservation.[5] Among the country reports, the majority pointed to decreases in cultivation of traditional varieties and landraces due to replacement by modern varieties.[6] Along with this conclusion, however, most of these country reports also stated that the detailed surveys and inventories that could document these decreases have not been done. The strongest conclusion that can be made from these country reports is that the extent of diversity maintained in crop production systems or in the wild either is not known or varies greatly with crop or ecosystem and country.

Among the strategies countries have reported to prevent genetic erosion caused by pressures for variety replacement are:

- on-going collection of wild and on-farm germplasm and diversification of production so that some farms still produce for local markets in rural areas and traditional uses with traditional cultivars (Bosnia Herzegovina);
- adequate conservation by the Nordic Gene Bank of landraces and traditional grass varieties (Iceland);
- absence of intensification of agriculture in many areas so that there is a continuing high number of varieties and species in cultivation (Former Yugoslav Republic of Macedonia);[7]
- since the late 1990s measures have been in place to protect habitat, promote continued landrace cultivation through farmer-participation projects, reintroduce landraces and old cultivars for organic production, and on-going collection missions (Poland); and
- on-going collection missions and promotion of on-farm conservation of heritage pasture, vegetable, and fruit tree varieties (Switzerland).

Many country reports have indicated that "informal" seed systems remain a key element in the maintenance of crop diversity on farms (See Chapter 4). It was noted in the Tanzania country report that such an informal system accounts for up to 90% of seed movement. Both the country reports of Finland and Germany called attention to EU Council Regulation No. 1698/2005, active in 2006 on the national and state levels. Under these regulations, payments can be made (premiums per hectare) for the cultivation of crop varieties threatened by genetic erosion as well as for specific actions supporting the conservation and sustainable use of these varieties.

Motivated by the coming into force of the ITPGRFA and the information arising from countries' efforts to meets its mandates, the Global Crop Diversity Trust was initiated and among its goals is the identification and addressing of the highest priority diversity conservation issues which involve *ex situ* conservation of the ITPGRFA mandate crops (listed in Annex 1 of the Treaty). Opening in 2008 was the Svalbard Global Seed Vault which will provide the ultimate global security backup collection for insurance against both incremental and catastrophic loss of crop diversity held in genebanks around the world. Since its opening there has been a concerted effort at depositing duplicate accessions from the CGIAR global collections and many national and regional collections.

Beginning in 2006, the Trust initiated the development of crop-based conservation and utilization strategies, convening teams of curators, breeders, and crop experts. The priorities that have emerged from this process were the next targets for the Trust, which now offers a grant process to fund work to address the priorities. The Trust's achievements in 2008 included signing over 50 grant agreements with partner organizations around the world to rescue, regenerate, characterize, evaluate, and ensure that the existing diversity, once better conserved and better understood, is quickly and easily available to plant breeders.[8]

In situ *conservation*

The wild forms of many crops (especially cereals and legumes) and most of the species in their primary and secondary genepools are usually annual species and thus populations are dynamic, and possibly transient, from year to year making it difficult for natural areas to be defined based specifically on conservation of CWRs. Most protected natural areas in the world are defined on the basis of geographic and ecological features and the presence of some dominant perennial plant taxa. Therefore the success of protected areas in maintaining annual CWR taxa is haphazard at best. An important effort at CWR conservation has been established by Bioversity International and partners with projects in five countries (see Box 2.1 in Chapter 2).[9]

On-farm conservation of old and heirloom varieties and landraces has been given impetus by many crop or food specific NGOs, public advocacy groups, and academic institutions. Several country reports have documented on-farm and participatory conservation efforts in those countries.[10] A major advance since the first SoW report has been the increasing numbers of national surveys and inventories supported by a wide range of organizations (see Chapter 2) that have documented the status of conservation efforts and priorities for further action.

Gaps

There are still gaps in the coverage of cultivars, traditional varieties, landraces, and CWRs in the *ex situ* collections of many major crops[11]. Similar gaps are found for collections of minor crops, but they are even more extensive in many cases. There is a better understanding of the extent and nature of gaps in *ex situ* collections now than was the case at the time of the first SoW report and there are many reasons. Some gaps arise by loss of once collected material. Others are due to lack of collection. Perennial taxa present special problems in regeneration, leading to loss and need for recollecting. *In situ* maintenance is often the better conservation option for perennial taxa from a genetic diversity standpoint.

The identification of gaps and recommendations for addressing them is a key component of the GCDT crop strategies. The CGIAR centers pursue these issues for their mandated crops. National PGRFA conservation programs in their country reports have documented needs in addressing gaps as well. Almost uniformly, the country reports cite needs for increased monitoring and establishment of early warning systems as a means to identify gaps in coverage and status of conservation.

Documentation, characterization, evaluation

Information systems vary greatly in type and sophistication from one collection to another. GIS and molecular data are used in the most sophisticated. Standardization and training are needed.[12]

Utilization

Constraints to utilization of germplasm accessions include lack of accession data, especially evaluation data, unavailability of useful material, and concern over IPR. Priorities to increase utilization include wider use of diverse mapping populations, enhanced use of mutant and genetic stocks and wild relatives, and deployment of newer technologies such as increasingly cost effective high-throughput marker detection and DNA sequencing technology.[13]

Participatory breeding approaches have increasingly emerged as a means to target production of cultivars tailored more specifically to farmers' needs, as noted by many country reports and summarized in Chapter 4. More specific discussion of the trends in utilization of PGRFA and the priorities for the near future is also in Chapter 4. Examples of priority needs include capacity building in both the crop improvement areas and the germplasm conservation areas and strengthened cooperation among those involved in the conservation and sustainable use of PGRFA at all stages of the seed and food chains.

Climate change

Many country reports document loss of diversity over the past decade from collections and farms due to the impacts of pest and disease outbreaks or to absence of tolerance for abiotic stresses, such as heat, drought, or frost, leading to loss of accessions during regeneration or in field collections or to the loss of cultivars or landraces during crop production. It is precisely these kinds of diversity losses that can be expected to increase with increasing manifestations of global climate change. Many country reports point to the threats of climate change for genetic resources. All the scenarios predicted by the Intergovernmental Panel on Climate Change (IPCC)[14] will have major consequences for the adaptation and geographic distribution of crops, specific varieties, and CWRs. Systems of protected areas and reserves will be impacted in ways that will require changes in scale, size, and management plans.[15] Regeneration and grow-out issues for *ex situ* collections will be even more critical to resolve because demand for accessions will increase if breeders are to be successful in finding and incorporating new sources of disease and pest resistance and stress tolerance into cultivars to facilitate crop adaptation to impacts of increasing climate diversity. However, as the country reports document and Chapter 4 summarizes, overall plant breeding capacity has not changed significantly since the first SoW report. There is thus an urgent need to increase this capacity worldwide to address the climate change crisis.

A4.2 STATE OF DIVERSITY OF MAJOR CROPS

A4.2.1 State of wheat genetic resources

Since 1995, the yield of wheat has increased only slightly (see Fig. A4.1). Wheat continued to be the most widely cultivated crop, harvested from 214 million hectares in 2007[16], down slightly from the 219 million hectares reported for 1995 in the first SoW report. Total world production in 2007 was 606 million tonnes[17], up from the 545 million tonnes reported for 1995. The five largest producers in 2007 were still China (18% of global production), India (13%), USA (9%), Russian Federation (8%), and France (5%).

World wheat production is based almost entirely on two species: common or bread wheat (*Triticum aestivum*, almost 95% of production) and durum or macaroni wheat (*T. turgidum* ssp. *durum*, about 5% of production)[18]. The former is a hexaploid species ($2n=2x=42$) and the latter tetraploid ($2n=2x=28$). Very minor, extremely local production may still be found with diploid wheats and tetraploid subspecies besides durum.

The genepool for wheats consists of modern and obsolete cultivars and breeding lines, landraces, related species (both wild and domesticated) in the Triticeae tribe, and genetic and cytogenetic stocks. Details of the genepool composition are described in the GCDT strategy plan[19]: The primary pool consists of the biological species, including cultivated, wild, and weedy forms of the crop species easily able to be hybridized. In the secondary genepool are species from which gene transfer is possible but with greater difficulty, typically species of *Triticum* and *Aegilops*. The tertiary genepool is composed of other species of the tribe (primarily annual species) from which gene transfer is possible only with great difficulty. 'Ease' of gene transfer is a technology-dependent concept and subject to change as are the taxonomic delimitations within the tribe. Wild relatives of wheat have proven to be highly useful sources of resistance to biotic and abiotic stresses in wheat breeding over the last two decades and this trend is expected to accelerate in the future. Similarly, genetic stocks are finding increasing use as tools in the sophisticated application of modern biotechnologies in wheat improvement.[20]

In situ *conservation status*

One of the few global examples of a protected area created specifically for conservation of annual cereal CWRs is the "Erebuni" State Reserve in Armenia, an 89 ha region in the transition area between semi-desert and mountain-steppe zones. Three out of the four known species of wild-growing wheat occur here (wild one-grain wheat, *T. boeticum*, wild two-grain Ararat wheat, *T. araraticum*, and wild urartu wheat, *T. urartu*) along with several species of *Aegilops*, in addition to a number of CWRs of other cereal species (barley and rye)[21]. Succession with other indigenous species and invasive species (both plants and animals) are threats to the integrity of the CWR species in this reserve as well as in any other in which cereal CWRs may be found. In general, any protected areas in countries with Mediterranean climates are likely to include some wheat CWR taxa. Whether the genetic integrity of such populations are being maintained in these reserves is the key question.

Ex situ *conservation status*

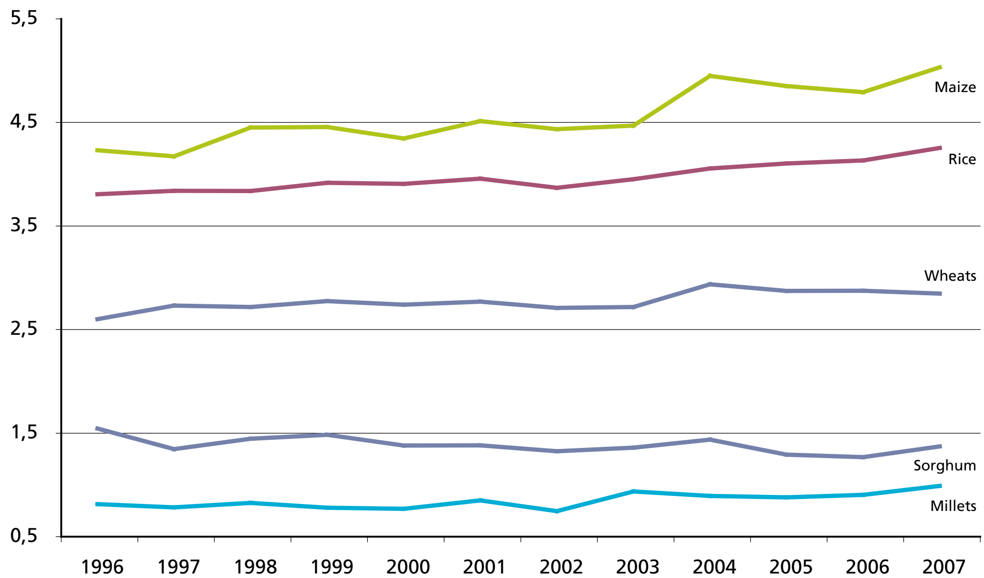
Landrace modern and obsolete improved cultivars are generally well conserved in wheat germplasm collections (more than 4200 collections with a total of around 935,000 accessions).[22] In comparison, wild relatives of wheats are poorly represented. Because of the specialized needs and conditions for developing and reliably maintaining genetic and cytogenetic stocks, they are not well represented in germplasm collections (probably in fewer than 90 collections) and are most likely to be found in research institutions. Regeneration progress is lacking in many country wheat collections and is probably the single greatest threat to the safety of wheat accessions held in globally important genebanks and lack of funding is the principle limitation.[23]

Genetic erosion and vulnerability

The instances of absence of genetic erosion or lack of vulnerability are rare. Chapter 1 highlights the increase in genetic diversity and allelic richness in varieties released from in the International Maize and Wheat Improvement Center's (CIMMYT) spring bread wheat improvement program. Many CWRs have a weedy habit and thrive in disturbed areas or areas of cultivation and thus are often widespread, but there is little known in general about the genetic diversity itself in these adventitious populations.

More typical are statements such as these: there is a gradual disappearance of landraces of wheat (Nepal Country Report); all primitive wheat cultivars are lost (Albania Country Report); and old varieties of wheat are replaced by modern cultivars in main production areas (both the Greece and Bosnia Herzegovina Country Reports).

FIGURE A4.1
Global yields of selected cereal crops (million tonnes per hectare)



Source: FAOSTAT 1996/2007

Gaps and priorities

As summarized in Chapter 3, 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. This divergence of perceptions of the major function of collections between genebank managers and germplasm users complicates evaluation of the status of diversity.[24] Crop wild relatives are relatively poorly represented in collections and more collecting is needed.[25] The level of genetic diversity and breadth of provenance of wild related species maintained in existing collections is small.

Safety duplication

Safety duplication is lacking for most country collections of wheat. Less than 10% of the globally important wheat collections have their entire collection duplicated elsewhere for safety, while a majority have only partial or no safety duplication in place.[26]

A4.2.2 State of rice genetic resources

Since 1995, the yield of rice (*Oryza sativa*) increased consistently (see Fig. A4.1). Rice accounted for 660 million tonnes of production (2007), cultivated over a harvested area of 156 million hectares[27]. The highest producers of rice in 2007 were China (28% of global production), India (22%), Indonesia (9%), Bangladesh (7%), and Viet Nam (5%).

The primary genepool has been source of useful genes for breeding and research. It consists of the other domesticated species (*O. glaberrima*) and *O. rufipogan* and several other wild species, all with a common genome (A), that can hybridize naturally with *O. sativa*.[28] The secondary and tertiary genepools, *Oryza* species with genome constitutions other than A, have potential as gene sources, but introgression of genes into rice is proving difficult.[29]

Genetic erosion and vulnerability

A sampling of the concerns raised by country reports include: the assessment that rice varieties have become more uniform and thus more genetically vulnerable (China), specific rice varieties and landraces have disappeared (Brazil, Madagascar, Mali, Nepal, Philippines, Sri Lanka), and wild species in the primary genepool are becoming extinct (China, Mali, Nepal, Nigeria, Thailand). Causes noted are increasingly unfavorable climate conditions, such as drought, replacement by introduced high-yielding, early-maturing varieties, and loss of habitat.

Gaps and priorities

Further collecting for better wild species representation (from all levels of genepools) in genebanks (as well as regeneration of existing wild accessions)and networks for sharing conservation responsibility for wild species among the several genebanks and research centers that maintain them are needed.[30]

Safety duplication

Seed multiplication and safety duplication is inadequate in most rice collections.[31]

Utilization

Improved conservation protocols would enhance utilization of accessions (e.g., glutinous rice accessions) that do not store well under moisture and temperature regimes of conventional storage conditions.[32]

A4.2.3 State of maize genetic resources

Since 1995, the yield of maize (*Zea mays*) increased overall with some modest drops along the way (see Fig. A4.1). Maize is grown over a harvested area of 158 million hectares with a global production of 792 million tonnes (2007),[33] having overtaken rice and wheat in production since 1995. The five highest producers of maize in 2007 were the USA (42% of global production), China (19%), Brazil (7%), Mexico (3%), and Argentina (3%).

The primary genepool includes the maize species (*Zea mays*) and teosinte, with which maize hybridizes readily with production of fertile progeny. The secondary genepool includes *Tripsacum* species (~16 species), some of which are endangered. The variability among maize landraces (some 300 have been identified) exceeds that for any other crop. Teosinte is represented by annual and perennial diploid species ($2n = 20$) and by a tetraploid species ($2n = 40$). They are found within the tropical and subtropical areas of Mexico, Guatemala, Honduras, and Nicaragua as isolated populations of variable population sizes, occupying from less than one ha to several hundreds of square kilometers. The distribution of teosinte extends from the southern part of the cultural region known as Arid America, in Mexico in the Western Sierra Madre of Chihuahua and the Guadiana Valley in Durango, to the western part of Nicaragua, including practically the entire western part of Mesoamerica.[34]

In situ *conservation status*

It is extremely important to act now to complete ecogeographic sampling for New World maize, since economic and demographic changes are eroding the genetic diversity of maize in many areas that were once untouched by modern agricultural, horticultural, forestry, and industrial practices.[35]

Ex situ *conservation status*

While there are relatively few areas where no comprehensive collection has already been made, maize from portions of the Amazon basin and parts of Central America and waxy maize in SE Asia were never adequately collected. Public or private tropical inbred lines are not well represented in collections either, nor are important hybrids (or their bulk increases).[36] Wild *Zea* and *Tripsacum* species are potentially important sources of genetic variation for maize, but they are not well represented in collections and existing accessions are in small quantities. The Maize Genetic Cooperation Stock Center at the University of Illinois is the primary genebank holding maize mutants, genetic stocks, and chromosomal stocks.[37] Teosinte representation is uneven and incomplete in major genebanks.[38]

Genetic erosion and vulnerability

As with wheat, a rare instance of improved genetic variability is the increase in genetic diversity and allelic richness in varieties released from CIMMYT's maize improvement program (Chapter 1). More typical is the report by individual countries of a loss of older varieties and landraces (Albania, Bosnia Herzegovina, Kenya, Nepal, Philippines). The predominant cause reported is replacement of traditional varieties by modern cultivars. All populations of teosinte are threatened.[39]

Gaps and priorities

National and international reserves need to be established to protect the remaining fragments of the Balsas, Guatemala, Huehuetenango, and Nicaraguan races of teosinte. CIMMYT's current *ex situ* tripsacum garden at Tlaltizapan, Morelos, should continue to be maintained, with a duplicate garden established in Veracruz (or some equivalent lowland, tropical environment). Another tripsacum garden could be established near IITA headquarters in Africa. *In situ* monitoring of tripsacum populations should be conducted in Mexico and Guatemala, the center of diversity for the genus, and in other countries in Central and South America, where both widespread and endemic species are found. *Ex situ* tripsacum gardens at CIMMYT and USDA in Florida should be enriched with the diversity found from the wild, and more collaboration should occur between these two unique sites.[40]

As summarized in Chapter 3, major gaps identified in existing *ex situ* maize collections include hybrids and tropical inbred lines, in addition to the gaps resulting from the loss of accessions from collections; for example, the entire collection of Dominica has been lost as has much of the material collected by IBPGR in the 1970s. The GCDT maize strategy emphasized specifically that hybrids and private inbred lines (not those now with PVP or with recently expired PVP) are missing from genebanks.[41]

There is a need to identify core subsets of the maize races, but it depends on expertise not only in statistical procedures, but more critically, in racial and accession classification and the availability of the type of data needed to develop reasonable classification decisions.[42]

While coverage of New World maize is good in genebanks,[43] about 10% of those New World holdings are in need of regeneration.[44] In some cases, recollection of adequate samples makes more sense than regeneration, particularly for high-elevation landraces growing in areas unaffected by improvement programs (much of Oaxaca and Chiapas in Mexico, many Central American highlands, much of Andean Argentina, Bolivia, Chile, Ecuador, Colombia, and Peru). Collection of indigenous knowledge must be a priority for all recollecting.[45]

Further collecting of wild species is needed, along with *in situ* conservation efforts. As with some landraces, recollecting of wild species is often more efficient than regeneration.[46]

Safety duplication

A network of safety duplicates for most accessions of major New World genebanks is in place. However, few of the accessions housed in the national collections of the Old World are backed up at the international centers; many are essentially unavailable to non-national (and sometimes even to national) users; and assurance of periodic regeneration is often uncertain.[47]

Safety backup for about 85% of the genetic stock collections is in place at the USDA NCGRCP, Ft. Collins CO USA.[48]

Because the genetic diversity of teosinte and tripsacum is relevant to maize research and breeding efforts for maize productivity, nutritional quality, bio-energy production, and other uses, *ex situ* backup of these materials is critical.[49]

Documentation, characterization, evaluation

Documentation of the materials held in national collections is inconsistent, and sometimes poor, and is held in multiple databases that are not necessarily well maintained or easily accessible. Standardization across databases is lacking. The most pressing problem is to resolve the various acronyms and numbering systems used for the same accession. Only the US-GRIN system is internet accessible.[50] Implementation of a global information system for maize is anticipated and it would serve especially to improve regeneration progress. A separate database may be useful for teosinte.[51]

An operational comprehensive maize metadatabase would make possible more efficient safety duplication for all accessions.[52]

Utilization

Increased use of germplasm may come about through improved for technology for distribution of DNA itself.[53]

Constraints noted for greater utilization include ownership issues and inadequate personnel. Distribution of accessions is hampered by IPR concerns.[54] There is a serious need to train a new generation of maize germplasm specialists in conservation and use.[55]

Role of crop in sustainable production systems

Strategic evaluation of maize germplasm accessions combined with genetic enhancement will be important to achieve enhancing food security, reducing poverty and protecting the environment, goals, particularly in Sub-Saharan Africa and in Indigenous areas of the Americas.[56]

A4.2.4 State of sorghum genetic resources

Since 1995, the yield of sorghum (*Sorghum bicolor*) has dropped (see Fig. A4.1). Sorghum was cultivated over a harvested area of 47 million hectares with a global production of 63 million tonnes (2007)[57]. Sorghum is mainly used for human consumption in Africa and India and for animal feed in the United States and China. The five highest producers of sorghum in 2007 were the USA (20% of global production), Nigeria (14%), India (11%), Mexico (10%), and the Sudan (9%).

The primary genepool consists of *S. bicolor* and its many races and several other species, the number of which depends on the taxonomic treatments.[58]

Ex situ *conservation status*

The major collections are the international one at ICRISAT and that of the USDA. Secondary are the national collections of China (CAAS) and of India (NBPGR). In addition, there are about 15 other institutions with germplasm (primarily national collections). Altogether, over 235,000 accessions are maintained. A high degree of duplication of accessions among collections is suspected, except for the Chinese collection which consists primarily of

Chinese landraces.[59] Cumulatively over all collections, about 4,000 accessions of wild materials are maintained.[60]

Genetic erosion and vulnerability

The Mali Country Report noted that 60% of local varieties of sorghum have disappeared in one region over 20 years due to the expansion of cotton production, introduction of maize cultivation, and the saturation of the available cropping area. In one village, diffusion of an improved variety displaced three local varieties of sorghum. Several other countries also indicated in their reports that improved varieties had displaced local varieties (Angola, Ethiopia, Malawi, Mali, Zambia, Zimbabwe). In Japan, sorghum is no longer cultivated at all, but the farmers' varieties were collected for the national gene bank (Japan Country Report). In Niger, however, no losses of varieties and landraces from farmers' fields had been detected in collecting missions (Niger Country Report).

Gaps and priorities

A massive number (28,000) of accessions urgently need regeneration, bottlenecks are quarantine, day length issues, labor costs, and capacities.[61]

Eco-sampling of the wild progenitors and landraces of *S. bicolor* in each of its primary, secondary, and tertiary centers of diversity is needed.[62] Further collection and conservation of wild close relatives is needed.[63] Gaps in geographic coverage were noted for West Africa, Central America, Central Asia and the Caucasus, and Sudan in Darfur and the south.[64]

Safety duplication

The status of safety duplication varies greatly from collection to collection.

Documentation, characterization, evaluation

While passport data are available for most accessions, the nomenclature used varies greatly among institutions making it difficult to target duplicates. Characterization data are documented electronically at a reasonable level, but evaluation data are lacking.[65] Aside from ICRISAT collection, most data are not accessible through internet.[66]

Utilization

Germplasm exchange and thus utilization is limited. Additional constraints on utilization are lack of useful trait information about accessions, decline in breeding programs, insufficient seed availability, and poor communication between breeders and conservers.[67]

Core and mini-core collections based on not only sampling available genetic diversity, but also on the basis of traits is needed.[68]

The two primary international collections have distributed most. The main recipients from the USDA have been public sector breeders, while from ICRISAT, recipients have been in-house research scientists (focus on crop improvement).[69]

Role of crop in sustainable production systems

As demand increases for more reliable food and feed sources from environments challenged by water shortage and high temperatures, sorghum will play a more prominent role due to its wide adaptation and diverse uses.[70]

A4.2.5 State of cassava genetic resources

Since 1995, the yield of cassava has had a net increase, although falling since 2006 (see Fig. A4.2). Cassava (*Manihot esculenta*) was grown over a harvested area of 19 million hectares with a global production of 215 million tonnes (2007).[71] The five highest producers of cassava in 2007 were Nigeria (16% of global production), Thailand (13%), Brazil (12%), Indonesia (9%), and the Democratic Republic of Congo (7%). Cassava is essential to food security in most regions of Africa.

The genepool consists of the cultivated *M. esculenta* and 70 to 100 wild *Manihot* species, depending on the taxonomic classification. Landraces, however, have been and will continue to be the primary sources of genes and gene combinations for new varieties. The wild species offer interesting traits (i.e. tolerance to post-harvest physiological deterioration, high protein content in the roots, resistance to pests and diseases), but are challenging to use and conserve.[72] The genus *Manihot* is native to the Americas, and most of the genetic diversification occurred there. Both Asia and Africa are important secondary centers of genetic diversity.[73]

The primary genepool consists of the cultivars themselves and species known to cross readily with cassava and yield fertile offspring: *M. flabellifolia* and *M. peruviana*, native to South America.[74] Taxa crossing with difficulty with cassava but giving some positive results make up the secondary genepool, including *M. glaziovii*, *M. dichotoma*, *M. pringlei*, *M. aesculifolia* and *M. pilosa*.[75]

In situ *conservation status*

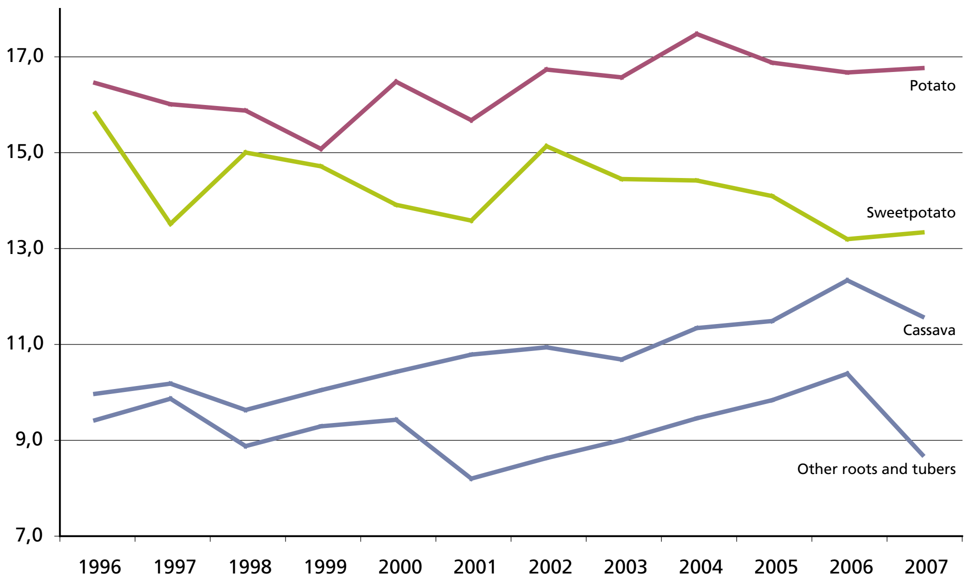
Despite long-standing proposals to create *in situ* reserves for wild *Manihot* species, this has not been realized.[76]

Ex situ *conservation status*

The primary conservation strategy is field collections, *in vitro* collections are employed to a lesser extent, followed by cryopreservation.[77] Seed storage as a method for germplasm conservation has received limited attention, but shows promise as a means of preserving genes and especially for many wild species which are difficult to maintain by the alternative methods and are seed propagated in the wild. Cassava seeds are apparently orthodox in behavior and therefore can be stored under conventional conditions of low humidity and low temperatures.[78]

Most cassava-growing countries have established a genebank of local landraces. Nearly all rely primarily on field-grown plants, but may have part of their collection under *in vitro* propagation as well. Two international centers (IARCs), CIAT and IITA, maintain regional collections for the Americas and Asia (CIAT) and for Africa (IITA). More than 32,000 accessions of cassava are stored *ex situ*.[79] Of these, 34% are estimated to be distinct landraces.[80] According to a GCDT study, in order to represent the complete genetic diversity of the species, additional collecting should be carried out.[81]

FIGURE A4.2
Global yields of root and tuber crops (million tonnes per hectare)



Source: FAOSTAT 1996/2007

Gaps and priorities

Field collections are not in good shape and there are backlogs within *in vitro* collections due to funding shortages. High maintenance of conservation and relatively short regeneration intervals are key bottlenecks.[82] CIAT has recently initiated a process to generate botanical seed through self-pollination of accessions in the cassava collection. The genotype of the accession is lost but its genes are preserved in the seeds produced.

Wild species are poorly represented in collections, both by species and by populations. Funding is a constraint. Further collection is needed, some species are at risk from expanding agriculture and habitat loss.[83]

Wild *Manihot* species are poorly represented in *ex situ* collections – only about one-third of the total species in the genus. Only EMBRAPA, Universidade de Brasilia (Nagib Nassar) and CIAT have a serious program for long-term conservation of wild *Manihot*.[84] The habitats of many populations are threatened by urbanization and expanding agriculture, especially in central Brazil. Effective collection and conservation are also compromised by the deficiencies in knowledge of taxonomy and phylogeny. Their *ex situ* conservation is difficult and needs intensive research to establish efficient and secure genebanks.[85]

Indexing methods for viruses that are exclusive to each continent are available, and these need to be refined and made broadly available to genebank managers and quarantine agencies.[86]

Safety duplication
Safe duplication is not complete.[87]

Documentation, characterization, evaluation
Little documentation is available in national collections. A global database is an urgent priority.[88]

Utilization
Few countries engage in international exchange of cassava germplasm on a regular basis.[89] Major constraints to utilization is lack of accession information and difficulty of exchange.[90]

In an effort to facilitate germplasm utilization, CIAT has initiated a process to generate partially inbred genetic stocks as source of desirable traits. Additional efforts needed to enhance utilization include disease indexing of accessions, development of better protocols for seed and *in vitro* conservation and cryoconservation, viability testing for pollen conservation, and improved seed germination protocols.[91]

Role of crop in sustainable production systems
Cassava is one of the most efficient crops in biomass production. In comparison with many other crops, it excels, under sub-optimal conditions, and can withstand drought conditions.

Most cassava production is still based on landrace varieties, although this is changing quickly, especially in the past decade, and in selected countries like Brazil, Colombia, Nigeria, Thailand and Viet Nam. Landraces are still used extensively in breeding programs as parents in crossing nurseries.[92]

A4.2.6 State of potato genetic resources
Since 1995, the yield of potato has been erratic from year to year, but overall the trend is an increase (see Fig. A4.2). Potato was cultivated in 2007 over a harvested area of 19 million hectares with a global production of 304 million tonnes.[93] The five highest producers in 2007 were China (18% of the global production), the Russian Federation (12%), India (7%), USA (7%), and Ukraine (6%).[94] Potato is important to food security particularly in America (North and South) and Europe.

The genepool can be divided into four types of germplasm: [95]

1. Modern cultivars (and old varieties) of the common potato (*Solanum tuberosum* ssp. *tuberosum*), the most cultivated potato subspecies in the world.
2. Native cultivars, including local potato cultivars occurring in the center of diversity (seven to 12 species depending on taxonomic treatment).
3. Wild relatives, consisting of wild tuber-bearing species and a few nontuber-producing species, occurring in the center of diversity (180 to 200 species depending on taxonomic treatment).
4. Other germplasm or research material; all types of genetic stocks e.g., interspecific hybrids, breeding clones, genetically enhanced stocks, etc.

Ex situ *conservation status*

Globally, about 99,000 accessions can be found *ex situ*, 80% of which are maintained in 30 key collections.[96] Accessions are conserved as botanical seeds or vegetatively as tubers and *in vitro* plantlets. Latin American collections contain many native cultivars and wild relatives and the collections in Europe and North America contain modern cultivars and breeding materials, as well as wild relatives.[97]

Genetic erosion and vulnerability

One example of erosion was provided by the Chile Country Report: before modernization of agriculture, peasant farmers on the Island of Chiloé cultivated 800 to 1,000 varieties of potato, now one finds only about 270 varieties.

Gaps and priorities

In Chapter 3, it was summarized that 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 any of those were lost, it would result in important gaps in the overall coverage of the genepool in collections.

The limited regeneration capacity is a constraint in all collections, especially for wild accessions and native cultivars. Genetic drift is becoming an issue in wild species collections where individual species are represented by too few accessions.[98]

Critical functions for optimal conservation such as regeneration, documentation, storage, health control, and safety duplication are not adequately performed in a number of genebanks. Several genebanks in Latin America and Russia do not have (access to) sufficient experience or facilities to keep the potato germplasm healthy.[99]

The extent of new collecting of wild material in center of diversity has been very limited in the past 10 years. Approximately 30 wild species are not yet represented in collections and may still need to be collected. In addition, for another 25 wild species, fewer than three accessions are present in the collections.[100]

Safety duplication

It is not clear in sufficient detail how many accessions of potato are currently safety duplicated.[101]

Documentation, characterization, evaluation

National collection databases are incomplete and not accessible.[102]

Utilization

Breeders prefer well-adapted germplasm of *Solanum tuberosum* spp. *tuberosum*, the most common potato, or research material with interesting properties.[103] The most serious constraint to utilization of collections is lack of information about accessions, especially characterization and evaluation data.[104]

The substantial amount of potato germplasm distributed to users indicates that germplasm is extensively used. There are, however, large differences in distribution between genebanks, ranging from a distribution from 23 to 7,630 accessions per year. Unfortunately, recipients or users do not consistently return information from their evaluation of the requested germplasm to the providing genebank.[105]

The domestic public sector makes most frequently use of germplasm, but some genebanks provide large number of accessions to the private sector (breeding companies). In South America and Canada farmers and NGOs intensively use the germplasm of the national genebanks. However, some genebanks distribute a substantial number of accessions to users abroad. NGOs and farmers use native cultivars and old varieties, often for crop production on-farm, and contribute with this activity to in situ conservation (regeneration, evaluation, and storage) of germplasm.[106]

A technological tool to enhance germplasm utilization would be widely available test kits for protection against viruses.[107]

A4.2.7 State of sweet potato genetic resources

Since 1995, the yield of sweet potato has been very erratic from year to year, with an overall decreasing trend (see Fig. A4.2). Sweetpotato (*Ipomoea batatas*) was cultivated over a harvested area of 8 million hectares with a global production of 127 million tonnes (2007).[108] The highest producers of sweet potato in 2007 were China (78% of global production), Uganda (2%), Nigeria (2%), Indonesia (2%), and Viet Nam (1%).

The genus includes 600 to700 species of which sweet potato is the only one cultivated. More than 50% are in the Americas. Sweet potato and 13 wild *Ipomoea* species closely related to sweet potato belong to the section Batatas; all of these, except *I. littoralis* are endemic to the Americas.[109]

Ex situ ***conservation status***

Globally, 35,549 accessions of sweet potato genetic resources are conserved, 80% of which are in less than 30 collections. These accessions include landraces, improved material, and wild *Ipomoea* species. The global collection maintained in CIP, Peru includes accessions from 57 countries, with Peru and other South American and Caribbean countries (primary centers of sweet potato diversity) as the most important contributors.[110] However, collection activities in the last 10 years produced only 1,041 accessions; most were improved material, followed by landraces.[111]

Some 162 CWR species are conserved in five collections, as seed. Thirteen of these species are especially closely related and are the focus of conservation efforts.[112]

Gaps and priorities

Chapter 3 notes that for sweet potato, the important geographic as well as trait gaps in collections have already been identified.

There are regeneration backlogs for most collections with 50 to 100% of accessions in some collections needing urgent regeneration. For collections holding wild accessions, 20 to 100% of the taxa need urgent seed regeneration. Many collections lack the capacity for *in vitro* regeneration or greenhouse conditions.[113] Most collections showed drawbacks and constraints in functions like plant health, documentation, regeneration, and safety duplication.[114]

Documentation, characterization, evaluation

Most collections have databases, but half are not computerized and only a few are internet accessible. Standardization is needed.[115]

Utilization

Optimization of conservation protocols would enhance utilization.[116]

Role of crop in sustainable production systems

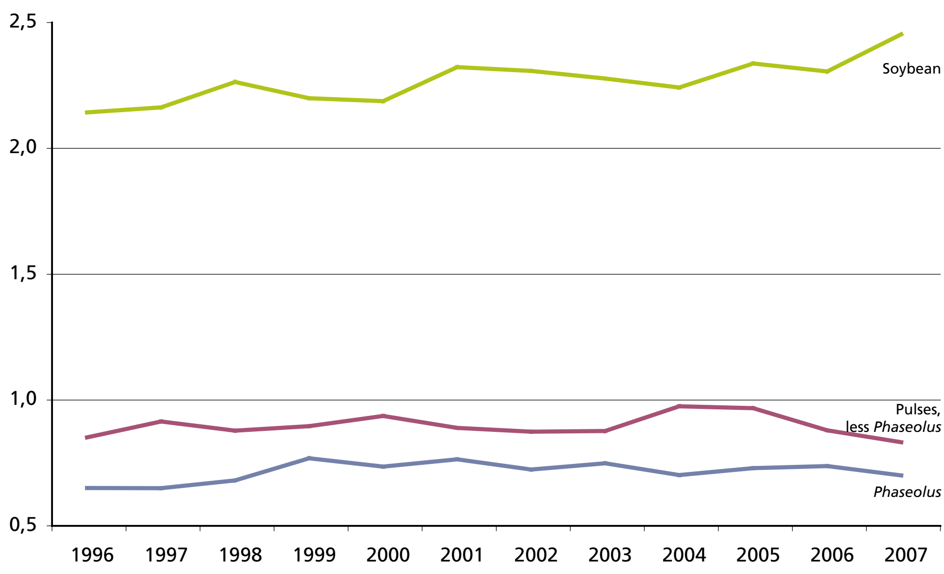
Sweet potato is a tropical perennial, cultivated as an annual in temperate climates; grown in more than 100 countries.[117]

A4.2.8 State of common bean genetic resources

Since 1995, the yield of common bean (*Phaseolus vulgaris*) has been essentially flat (see Fig. A4.3). Dry beans were grown over a harvested area of 27 million hectares with a global production of 18 million tonnes in 2007[118] (excluding production from intercropped fields). The six highest producers are Brazil (17% of global production), India (16%), Myanmar (10%), China (7%), USA (6%), and Mexico (5%).

The common bean primary genepool consists of the cultivars and wild forms of *P. vulgaris*. The primary genepool has two distinct geographic components: the Andean zone and the MesoAmerican zone with domestication presumed to have occurred independently in each zone. The secondary genepool consists of *P. costaricensis*, *P. coccineus*, and *P.*

FIGURE A4.3
Global yields of selected legume crops (million tonnes per hectare)



Source: FAOSTAT 1996/2007

polyanthus, crosses of each with common bean result in hybrid progeny without any special rescue efforts, but the progeny can be partially sterile and difficult from which to retrieve stable common bean phenotypes. The tertiary genepool consists of *P. acutifolius* and *P. parvifolius*, crosses of either with common bean need embryo rescue to produce progeny.[119,120]

Ex situ *conservation status*

CIAT in Peru is the primary global collection with some 14% of the world's approximately 264,000 genebank accessions of common bean.[121]

Genetic erosion and vulnerability

Genetic erosion is reported by several country reports for common bean and related taxa overall (e.g., Costa Rica Country Report) and, more specifically, cultivars have disappeared due to pathogen outbreaks (Madagascar Country Report), eight years of recurring droughts (Namibia Country Report), and replacement by introduced varieties (Tajikistan Country Report).

A4.2.9 State of soybean genetic resources

Since 1995, the yield of soybean (*Glycine max* (L.) Merrill) has varied up and down from year to year, but with an overall increase (see Fig. A4.3). Soybean was grown in 2007 over a harvested area of 90 million hectares with global production of 221 million tonnes.[122] The five largest producers of soybean in 2007 were USA (33% of global production), Brazil (26%), Argentina (22%), China (6%), and India (5%).

The genus *Glycine* includes about 20 annual and perennial species distributed primarily in Australia and Asia. The primary genepool consists of the cultivated forms of *G. max*, the annual wild soybean, *G. soja* (considered the immediate ancestor of the cultivated soybean), and a weedy species *G. gracilis*, with its diversification center in China, Korea, Japan, and the Far East region of Russia. The secondary genepool consists of the other wild species of *Glycine*, and the tertiary genepool is considered to be species in the legume tribe Phaseoleae.[123]

Ex situ *conservation status*

The Institute of Crop Germplasm Resources, Chinese Academy of Agricultural Sciences (ICGR-CAAS) maintains the primary global collection with some 14% of the world's approximately 230,000 genebank accessions of soybean.[124] Soybean is not one of the crops covered under the ITPGRFA.[125]

Genetic erosion and vulnerability

The extensive cultivation of a few high yielding soybean varieties on an exceptionally massive scale has caused tremendous genetic erosion of the soybean genepool. The genetic base of USA soybean production has a very narrow base and many traditionally grown Chinese landraces can only be found in genebanks today.[126]

A4.2.10 State of major sugar crop genetic resources

Sugarcane (*Saccharrum officinarum*) and sugarbeet (*Beta vulgaris*) are the two primary species used for sugar production. The global yield of sugarcane, accounting for about 70% of produced sugar, has varied greatly since 1995 with a period of low yields in 2000 through 2003, but ending with a net increase (see Fig. A4.4). Sugarcane was cultivated in 2007 over a harvested area of 23 million hectares with a total global production of 1,591 million tonnes.[127] The six largest producers of sugarcane in 2007 were Brazil (35% of global production), India (22%), China (7%), Thailand (4%), and Pakistan and Mexico (3% each).

The cytotaxonomy and species relationships generating what today is the sugarcane crop plant are complex. The crop is of hybrid origin, the taxonomic status of the genus is not settled, and there may have been multiple domestication events.[128] Therefore the genepool definitions are also complicated. One presentation is that there are four species in genus *Saccharum*: *S. officinarum*, the 'type' cane of the genus, not known in the wild; *S. robustum*, the wild ancestor of *S. officinarum*, *S. spontaneum*, a more primitive wild ancestor than *S. robustum*; and *S. barberi*, with an unclear origin, one possibility is that it is of hybrid origin. Two separate origins for the domesticates are postulated: India and Papua New Guinea.[129] These four species would comprise the primary genepool of sugarcane and cultivars today are predominantly of hybrid origin from crosses between *S. officinarum* and one of the other species. In general, hybrid seedlings are more resistant to diseases and more adaptable to climate variables than is *S. officinarum*.[130]

A broader genepool is accessible, termed the *Saccharum* complex, and includes other genera now thought to be involved in the origin of sugarcane: *Erianthus*, *Ripidium*, *Sclerostachya*, *Narenga*, and possibly *Miscanthus*.[131]

Sugarbeet production wasn't analyzed in the first SoW report, but the global yield of sugarbeet has also varied since 1995, with the perturbations coming in 2000 through 2003. There was a net increase in production by 2007 (see Fig. A4.4). Sugarbeet was cultivated in 2007 on a harvested area of 5.2 million hectares with a total global production of 247 million tones.[132] The five largest producers of sugarbeet in 2007 were France and the USA (each with 13% of global production), Russian Federation (12%), Germany (10%), and Ukraine (7%).

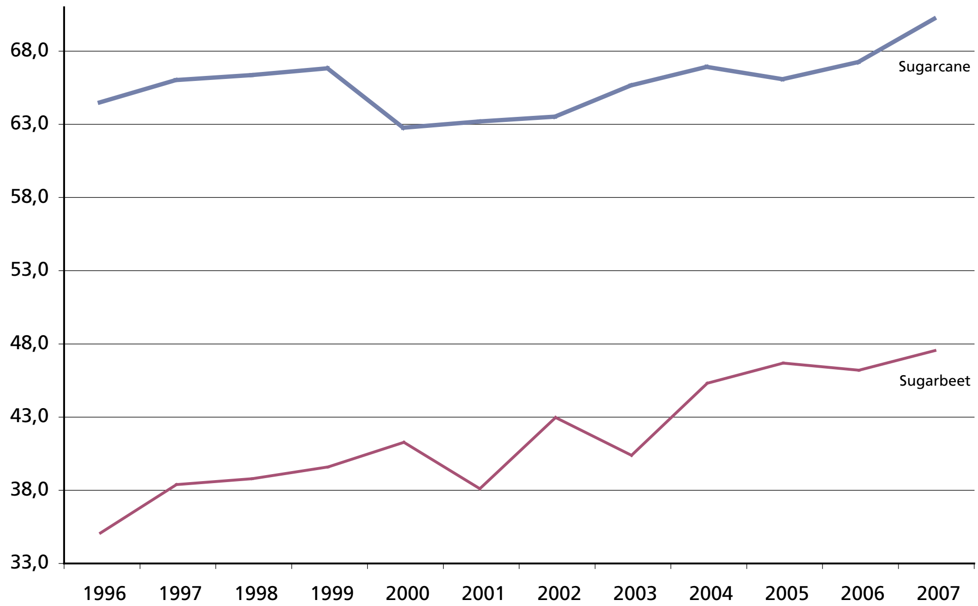
Gene pool

The genetic base of the sugarbeet crop (open pollinated) is considered narrow. The immediate progenitor is the wild sea beet, a conspecific subspecies to the crop.[133] The primary genepool is the species in section *Beta* of genus *Beta*, in which the crop is also classified; two other of the four sections of the genus comprise the secondary genepool (*Corollinae* and *Nanae*), and the fourth section *Procumbentes* comprises the tertiary genepool.[134]

Ex situ *conservation status*

The Centro de Tecnologia Canavieira collection of sugarcane germplasm in Brazil is the largest global collection with 12% of the world's approximately 41,000 accessions; the Instituto Nacional de Investigación de la Caña de Azúcar in Cuba is second with 9%.[135]

FIGURE A4.4
Global yields of sugar crops (million tonnes per hectare)



Source: FAOSTAT 1996/2007

The USDA collection of sugarbeet germplasm in the USA is the largest global collection with 11% of the world's approximately 22,500 accessions; the Genebank of the Leibniz Institute of Plant Genetics and Crop Plant Research in Germany and Institute for Field and Vegetable Crops in Serbia are close seconds with 10% each.[136]

Genetic erosion and vulnerability

The Belgium Country Report notes there has been a reduction in sugarbeet varieties cultivated.

A4.2.11 State of banana/plantain genetic resources

Since 1995, the yields of banana and plantain (species in genus *Musa*) have varied slightly, ending with net increases (see Fig. A4.5). Bananas and plantains were each grown in 2007 over harvested areas of 5 million hectares each, 10.5 million hectares in total, with a global production of 120 million tonnes (86 and 34 million tonnes, respectively).[137] The five largest producers of banana in 2007 were India (25% of global production), China and the Philippines (9% each), Brazil (8%), and Ecuador (7%). For plantain, the largest producers were Uganda (32% of global production), Ghana and Nigeria (9% each), and Colombia and Rwanda (8% each).

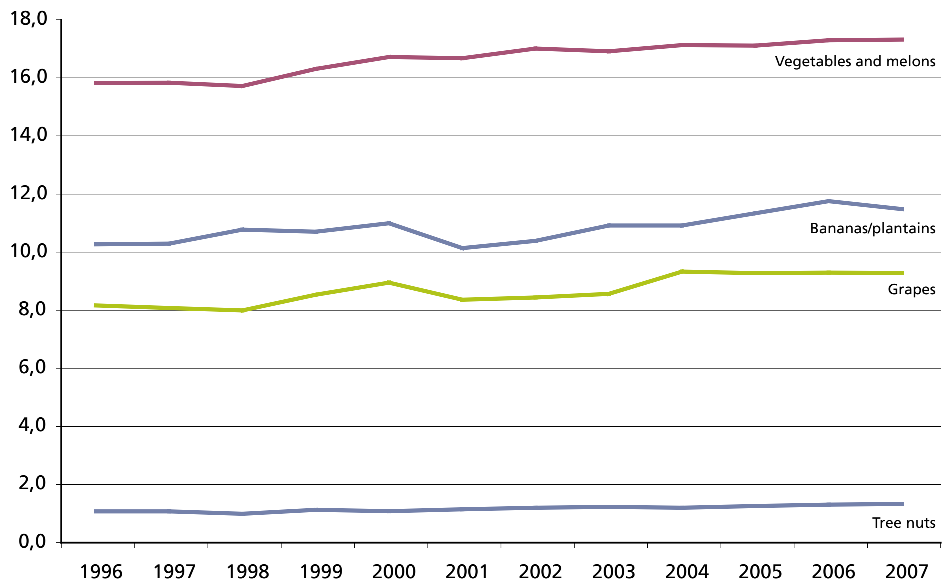
The genus *Musa* represents a group of approximately 25 forest-dwelling species, divided into four sections, distributed between India and the Pacific, as far north as Nepal and extending to the northern tip of Australia. The genus belongs to the family Musaceae, which also comprises some seven species of *Ensete* and possibly a third, monospecific, genus *Musella*, which is closely related to *Musa. Musa acuminata* ssp. *banksii* is believed to be the ancestral parent of the majority of edible banana cultivars, contributing what is called the 'A' genome while *Musa balbisiana* contributed the 'B' genome to several banana cultivar groups and all plantains. The largest portion of the genepool is in the form of 12 cultivar types or genome groups.[138]

A secondary region of diversity is in Africa where the crops were introduced some 3000 years ago and radiated into more than 60 cooking types in the highlands of East Africa and 120 plantain types in West and Central Africa.[139] An additional group of edible bananas, known as Fe'I bananas, are confined to the Pacific. Their genetic origin is obscure, but taxonomic studies suggest ancestral links either with the wild species *Musa maclayi* or *M. lododensis*.[140]

Ex situ *conservation status*

About 13,000 accessions of *Musa* are reportedly conserved *ex situ*. Thirty-nine collections world-wide conserve each more than 100 accessions. Altogether they account for 77% of the total number of *Musa* accessions reportedly conserved *ex situ*.[141] Wild species offer potential for genetic diversity for such traits as resistance to abiotic stresses and tolerance to cold, water logging, and drought.[142] CWRs currently account for 15% of the global collection.[143]

FIGURE A4.5
Global yields of sugar crops (million tonnes per hectare)



Source: FAOSTAT 1996/2007

The vast majority of the 60 or so *Musa*-dedicated national collections manage the majority of their accessions as full-sized plants in field collections. As part of a GCDT study, twenty-five field collections were surveyed and reported to hold slightly more than 6000 accessions in total. Of these institutions, 15 hosted *in vitro* collections containing slightly more than 2000 accessions. In addition, the INIBAP Transit Center (ITC) holds an additional 1176 accessions *in vitro*. The *in vitro* collections are used for safety duplication of the field collections and for rapid multiplication and dissemination of disease-free planting material. About 13 national collections also have international recognition and several contribute to the long-term conservation goals of the ITC global collection.[144]

Two cryopreservation protocols are available for a range of banana cultivar groups and the ITC is implementing a program of cryopreserving its entire collection as a more cost-effective alternative for backup.[145]

Genetic erosion and vulnerability

Sixty-two percent of national collections of banana are deteriorating due to management limitations.[146]

Hurricane impacts in Grenada have resulted in severe losses to banana production, which is one of the top three major traditional crops.

Gaps and priorities

It is reported in Chapter 3 that one of the best estimates of genepool coverage is available for banana and plantain. About 300 to 400 key cultivars are known to be missing from the ITC including 20 plantains from Africa, 50 *Callimusa* from Borneo, 20 to 30 *M. balbisiana* and 20 other types from India and China, 10 accessions from Myanmar, 40 wild types from Thailand and Indonesia, and up to 100 wild types from the Pacific.

Wild species account for about 15% of the collection and improved varieties amount to about 10%. New wild species and varieties continue to be described and are inadequately represented in collections. Threats posed by habitat destruction and the replacement or loss of traditional cultivars intensify the urgency for collection and conservation efforts. There is a need for larger quantities of virus-indexed material within regions.[147]

Safety duplication

Field collections are safety duplicated with *in vitro* collections.[148]

Utilization

Better descriptor and characterization information is a priority to facilitate use of banana germplasm. In addition, development and implementation of cryopreservation of protocols for banana accessions would make them more available for use.[149] While diversity is demanded by researchers and growers, many national collections and large parts of major collections are underutilized. For example, 70% of the ITC collection have not been requested and remain unused. A partial reason is inadequate documentation of holdings.[150]

Most national collections regularly or occasionally exchange germplasm with the ITC and since its establishment the ITC has distributed more than 60,000 germplasm samples of 450 accessions to 88 countries. Accessions are supplied without fee, but a maximum of only five plants is made available per accession. Some national and regional collections also distribute to international users. Most national collections are directly associated with breeding initiatives and many provide material directly to farmers.[151]

A4.3 STATE OF DIVERSITY OF MINOR CROPS

A4.3.1 State of millet genetic resources

Since 1995, the yield of millets has increased only slightly (see Fig. A4.1). Millets were grown over a harvested area of 35 million hectares with a global production of 34 million tonnes (2007).[152] They are often dual-purpose crops (human consumption and animal feed) and are important staple foods in Africa and India. The highest producers in 2007 were India (37% of global production), Nigeria (24%), Niger (8%), China (5%), Mali (3%), and Burkina Faso (3%).[153] Millets include the major millet, pearl millet (*Pennisetum* spp.), and minor millets such as finger millet (*Eleusine coracana*), Japanese barnyard millet (*Echinochloa frumentacea*), common or proso millet (*Panicum miliaceum*), and foxtail millet (*Setaria italica*).

Ex situ *conservation status*

The primary global collection of pearl millet is ICRISAT with 33% of the world's approximately 65,400 genebank accessions.[154] The ICGR-CAAS in China maintains 56% of the world's approximately 46,600 accessions of *Setaria*. The Indian National Bureau for Plant Genetic Resources maintains the largest *Eleusine* collection with 27% of the world's approximately 35,400 accessions. The National Institute of Agrobiological Sciences in Japan maintains the largest *Panicum* collection with 33% of the world's approximately 17,600 genebank accessions.

Genetic erosion and vulnerability

A number of studies and reports call attention to reduction in diversity of farmers' varieties and landraces in cultivation: traditional pearl millet varieties in Niger decreased as improved varieties were adopted by farmers;[155] absence of an early warning system threatens the diversity of indigenous cultivation of millets (Ghana Country Report); comparison of the number of landraces of finger millet found now in cultivation to that from 10 years ago showed serious genetic erosion had occurred (Malawi Country Report); there has been a gradual disappearance of landraces of native cultivated millets such as *Paspalum scrobiculatum*, *Setaria italica*, and *Panicum miliare* (Nepal Country Report); rice is replacing millet (Sri Lanka Country Report); and high-yielding modern varieties of several millet species are replacing tradition varieties of those millets (Yemen Country Report).

A4.3.2 State of root and tuber crop genetic resources, other than cassava, potato, and sweet potato

Since 1995, the yield of roots and tubers other than those treated separately above appeared to have increased through 2006, but data from 2007 showed a drop in yield to a value lower than that in 1996 (see Fig. A4.2). Roots and tubers, other than cassava, potato, and sweet potato,[156] were grown in 2007 over a harvested area of 8 million hectares with global production of 66 million tonnes.[157] The six largest producers in 2007 were Nigeria (with

55% of global production), Côte d'Ivoire (9%), Ghana and Ethiopia (each with 8%), and Benin and China (each with 3%).

Taro (*Colocasia esculenta*) and **yam** (species of *Dioscorea*) account for the bulk of this miscellany of roots and tubers. Others are **ulluco** (*Ullucus tuberosus*), **yautia or new cocoyam** (*Xanthosoma sagittifolium*), and **giant swamp taro** (*Cyrtosperma paeonifolius*) with regional importance in the Andes, West Africa, and Melaniesia, respectively. Individually, these are all minor crops when considered on a global scale. Accordingly, research on diversity, basic biology, and species relationships has been minimal. Most is known for **taro**. There are two major genepools for **taro**: Southeast Asia and Southwest Pacific regions.[158]

Ex situ *conservation status*

Seed collections are not part of any aroid conservation strategies.[159] For **taro**, most collections are entirely field collections, with little use of *in vitro* conservation, and these suffer from losses, especially due to diseases. Many have been abandoned. The primary risk is the high cost of maintenance.[160]

Taro genebanks have been established in all countries (Indonesia, Malaysia, the Philippines, Thailand, Vietnam, Papua New Guinea, and Vanuatu) working with Wageningen Agricultural University, The Netherlands, in a collaboration (TANSAO) aimed at improving **taro** production in Southeast Asia. From the 2,300 assembled accessions (complete with passport and characterization data), a core collection of 168 was selected based on morphological and DNA data as representative of the diversity found in the region.[161]

There are also **taro** collections in China and India and they are characterized morphologically but no molecular information is available and no core collections from them have been established.[162]

Worldwide **taro** *ex situ* holdings reportedly account for a total of about 7,300 accessions.[163]

Genetic erosion and vulnerability

Both the number of farmers' varieties and wild species of **taro** have decreased globally in the last 10 years and disease threats and replacement in production by sweet potato are among the causes in reduction in diversity of global **taro** cultivation.[164] Similarly at national levels, other reductions in diversity are reported: Wild **yam** species are considered likely to disappear soon (Madagascar Country Report). Erosion of yam diversity is occurring both from traditional areas of cultivation and from the wild (Kenya Country Report). The indigenous diversity of **cocoyam** is under threat, in the absence of an early warning system to assess genetic erosion (Ghana Country Report). The market chain for some crops (e.g., species of *Colocasia* and *Xanthosoma*) is still poorly developed, and undervaluing of local crop varieties has partly contributed to the loss in diversity in such crops (Uganda Country Report). A study in several regions of Peru indicates that genetic erosion is ongoing in the crop species **oca**, **ulluco**, and **mashua**, as well as in some related wild species (Peru Country Report). There is genetic erosion in **yam** species other than *Dioscorea alata* and cassava, attributed to acculturation, industrialization, and deforestation (Philippines Country

Report). In its country report, Papua New Guinea claims that all root crops are threatened by replacement by rice cultivation and loss of traditional beliefs. Specifically, **taro** is threatened by the taro beetle, **yam** by labor shortages and replacement by introduced African yam, and **taro kongkong** by root rot disease. Weather catastrophes can play a role in cultivar attrition. Prior to Hurricane Ivan in 2004, the island of Grenada was self sufficient in root and tuber crop production, which has severely decreased since then (Grenada Country Report).

Gaps and priorities

Further collection of CWR is needed. There are gaps in collections for **taro** wild species representation, especially for wild **taro** and **giant swamp taro**.[165]

Many sources point out the need for funding and organization of networks for the many root and tuber crops to ensure cost effective and efficient study and conservation of these diverse taxa.

Safety duplication

There is a core collection of **taro**, that is well duplicated. The only collection of **giant swamp taro** is a field collection and needs duplication (preferably by *in vitro* propagation).[166]

Documentation, characterization, evaluation

Major international germplasm databases do not include edible aroids and where there is existing information it is often invalid.[167]

Utilization

The low use of **taro** and other aroid collections has led to vulnerability of those collections. Better coordination between improvement programs and collections is needed. Cryopreservation protocols for taro would enhance germplasm availability.[168] The **taro** collections of most countries are not being used in improvement programs, adding to their vulnerability due to the high costs involved in their upkeep. Only in India, Papua New Guinea, and Vanuatu are **taro** collections part of crop improvement programs.[169]

There is considerable research interest in CWR of several root and tuber crops due to their high allelic diversity. Markers to allow MAS are priorities.[170]

All the countries with major collections distribute **taro** germplasm within the country, albeit a modest amount, but none outside, except for Vanuatu and the Secretariat of the Pacific Community's Regional Germplasm Center in Fiji. Other researchers, including breeders, are the most common recipients, rather than farmers and extension personnel. There is an indication from most countries that the amount of germplasm distributed is on the increase.[171]

Role of crop in sustainable production systems and organic production systems

In all countries where it is grown, **taro** plays an important role in food and nutritional security. It has a value for sustainable agriculture in midland and upland areas of Viet Nam and the Philippines. In addition to being an important food crop with high cultural value, taro is also a cash crop.[172]

Giant swamp taro plays an important role in food and nutritional security in Melanisia and Micronesia.[173]

For some crops (e.g., *Colocasia* spp. and *Xanthosoma* spp.) niche markets exist that can be strengthened, providing a source of income for vulnerable groups such as women (Uganda Country Report).

A4.3.3 State of pulse crop genetic resources, other than *Phaseolus*

Since 1995, the yield of pulses other than *Phaseolus* species was not greatly variable, declining in the last two years to a level about equal to that in 1996 (see Fig. A4.3). Pulses,[174] not counting *Phaseolus* species, were grown in 2007 over a harvested area of 46 million hectares with global production of 38 million tonnes.[175] The eight largest producers in 2007 were India (with 30% of global production), Canada (10%), China (7%), Ethiopia (4%), and Russian Federation, Turkey, Nigeria, and Australia (each with 3%).

Lentil (*Lens culinaris)*, is one of the founding crops of agriculture, domesticated at about the same time as wheat and barley in the Fertile Crescent, from today's Jordan northward to Turkey and southeast to Iran. A substantial portion of global lentil production is still concentrated in this area. However, the largest producers of lentils are India and Canada. The progenitor of lentil is identified as the wild subspecies *L. culinaris* spp. *orientalis*, which looks like a miniature cultivated lentil and bears pods that burst open immediately after maturation. Selection by early farmers around 7000 BC led to the cultivated species with nondehiscent pods and nondormant seeds, more erect habit, and a considerable increase in seed size and variety in color. The crop has developed into a range of varieties adapted to diverse growing areas and cultural preferences, and containing unique nutritional compositions, colors, shapes, and tastes.[176]

Taxa contained within *L. culinaris* comprise the primary genepool for lentil. The three other species in the genus constitute the secondary-tertiary genepool. All four species are diploid ($2n$=14), annual, and self pollinating with a low outcrossing frequency.[177]

The genus ***Cicer*** comprises 42 wild species and one cultivated species, **chickpea** (*Cicer arietinum*). **Chickpea**, or garbanzo, is a crop of relatively minor importance on the world market, but is extremely important to local trade in numerous regions within the tropics and subtropics. Populations of what were botanically classified as a species distinct from *C. arietinum* were found by botanists in southeast Turkey and named *C. reticulatum*. However, they are cross fertile with and morphological similar to domesticated chickpea and possibly represent wild forms of the crop species. This would suggest that chickpea was domesticated in present-day Turkey or in the northern parts of Syria or Iraq.[178]

The primary genepool for **chickpea** consists of varieties, landraces, *C. reticulatum*, and *C. echinospermum*. One of the species in the secondary genepool is *C. bijugum* and it is considered a priority for collection.[179]

Vicia is a large genus of 140 to 190 species, chiefly located in Europe, Asia, and North America, extending to temperate South America and tropical East Africa. Primary diversity for the genus is centered in the Near East and Middle East, with a large percentage of the species occurring in the Irano-Tauranian floristic region. Approximately 34 of the species have been utilized by humans. *V. faba* (faba bean) is cultivated primarily for its edible seeds, while a number of other species (*V. sativa, V. ervilia, V. articulata, V. narbonensis, V. villosa, V. benghalensis*, and *V. pannonica*.) are cultivated as a forage or grain legume for livestock, or for soil improvement.[180]

The wild progenitor and the exact origin of faba bean are unknown. In practice, a continuous variation in *V. faba* for most morphological and chemical traits has been observed, making discrete differentiation of varieties challenging.[181]

The **grasspea** genus ***Lathyrus*** comprises approximately 160 species, primarily native to temperate regions of the world, with approximately 52 species originating in Europe, 30 in North America, 78 in Asia, 24 in tropical East Africa, and 24 in temperate South America. Five *Lathyrus* species are grown as a pulse—i.e. that are harvested as a dry seed for human consumption: *L. sativus, L. cicera*, *L. ochrus* and, to a lesser extent, *L. clymenum.* Another species that is occasionally grown for human consumption—but for its edible tubers rather than its seed—is *L. tuberosus*, known as the tuberous pea or earthnut pea.[182]

In situ *conservation status*

While perennial *Cicer* species should be collected before they are extirpated, regeneration of them is problematic. Ideally conservation strategies for *in situ* conservation should be developed for these taxa.[183]

As reported in the GCDT *Vicia faba* conservation strategy, creation of *in situ* conservation measures have been recommended for members of *Vicia* subgenus *Vicia* in the Eastern Mediterranean region, specifically Turkey, Syria, Lebanon, Israel, Iraq, Iran and the Caucasian Republics, with targeted sites encompassing the distinct ecogeographic preferences of individual taxa. The species within the subgenus most seriously threatened by extinction were shown to be restricted to Syria, Lebanon, Turkey, and Israel; the highest concentration of potentially threatened taxa are located in Syria.[184]

Ex situ *conservation status*

The **lentil** collection at ICARDA is the single international collection and it is also the largest lentil germplasm collection holding 19% of the total world collections (58,400 accessions). There are 43 other national collections conserving more than 100 accessions each. The bulk of the accessions of most of these collections are landraces which were collected in more than 70 countries.[185]

Similarly, the **faba bean** collection at ICARDA is the single international collection and it is also the largest faba bean germplasm collection holding 21% of the total world collections (43,720 accessions). There are 53 other national collections, each maintaining more than 100 accessions. The bulk of the accessions of most of these collections are landraces originated from more than 80 countries.[186]

The two global **chickpea** collections (ICRISAT and ICARDA) hold about 33% of the total world collections (98,313 accessions). There are 48 other national collections with more than 100 accessions each. The bulk of the accessions of most of these collections are landraces from more than 75 countries.[187] Although the holdings of the wild species of *Cicer* are small (7%) compared to the cultivated species *C. arietinum*, they are potentially very important for research and crop improvement.[188]

The **grasspea** collection at ICARDA is the single international collection and the second largest grasspea germplasm collection holding 12% of the total world collections which are comprised of few large collections and several small but key collections, having a high proportion of indigenous accessions. The collection maintained in France is the largest. There are about 62 other national collections whose number of accessions is greater than 50. Landraces and wild materials comprise the bulk of the accessions themwhich originate from about 90 countries.[189]

The majority of **chickpea**, **grasspea**, **faba bean**, and **lentil** collections reported that they have long-term storage conditions available, however, there is no guarantee that uniform criteria were used or understood to define 'long-term' by each reporting collection. Similarly the assessments of needs for regeneration are not necessarily reported by each collection using standard protocols and seed viability measures. It is probable that for many collections, long-term storage security, regeneration, and multiplication represent major constraints for security of accessions, especially for perennial, wild, and out-crossing accessions.[190,191,192,193]

Genetic erosion and vulnerability

Country reports documented a wide variety of instance of concern and measure of loss or reduction in genotypes of many pulse crops:

- There is genetic erosion in ***Hedysarum humile***, **chickpea**, **pea**, **lupin**, and **lentil**; for wild, endemic taxa attention isn't paid to diverse biotypes (Algeria Country Report).
- The indigenous diversity of **bambara groundnut** is under threat in the absence of an early warning system to assess genetic erosion (Ghana Country Report).
- Comprehensive studies on **cowpea** were conducted to quantify the level of genetic erosion. As judged by number of landraces found in cultivation now compared to 10 years ago, serious genetic erosion has occurred (Malawi Country Report).
- **Food legumes** are at risk because of drought, increased use of new commercial varieties, and some crop-specific pests and pathogens (Morocco Country Report).
- In Zimbabwe, recurrent droughts, most notably the 2002 cropping season, and flooding induced by cyclones have resulted in substantial loss of *in situ* plant diversity. Disaster recovery programs led by the government, in most cases, focused on providing chiefly hybrid seed of **cowpea**, **beans**, and **groundnuts**, and fertilizers. There are no records of attempts to restore the landraces and other plant genetic diversity of the affected areas, which suggests that material lost was not recovered (Zimbabwe Country Report).
- There is gradual disappearance in Nepal of landraces of **cowpea** and of native cultivated species such as *Vigna angularis* and *Lathyrus sativus* (Nepal Country Report).
- Various local races/cultivars of **chickpea**, **lentil**, **mung**, and **mash** were observed to be lost in recent years from farmer's fields (Pakistan Country Report).
- There is genetic erosion in **mungbean**, **yardlong bean**, and **cowpea** (Philippines Country Report).

Gaps and priorities

For **lentil**, landraces from Morocco and China and wild species, particularly from southwest 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, *V. faba* ssp. *paucijuga,* is also underrepresented in collections and there are trait gaps, especially for heat tolerance. Geographic gaps for **grasspea** include the Russian Black Sea coast and Volga-Kama region, the Kurdish area of Iraq, Northeast and Eastern India, high altitude areas of Ethiopia, Northeast and Central Afghanistan, and the Andalucia and Murcia regions of Spain. An important consideration for many legume collections is the need to also collect and maintain samples of rhizobia. This is especially the case for wild legume species, but such rhizobia collections are rare. (see Chapter 3)[194,195,196,197]

There are regeneration needs for **chickpea**, **grasspea**, **lentil**, and wild species of **pigeonpea.**[198]

Landraces of **lentil** in Morocco and in China as potentially undersampled and hence underrepresented in germplasm collections.[199]

Landraces of **chickpea** from the Hindu-Khush Himalayan region, west and northern China, Ethiopia, Uzbekistan, Armenia, and Georgia are underrepresented in collections. The world collection covers very little of the wild distribution for the *Cicer* genus, thus the accessions in *ex situ* collections represents only a fraction of the potential diversity available in wild populations.[200]

Species related to **chickpea** and **lentil** are greatly undersampled geographically in collections. Species related to **grasspea** are poorly known and both **grasspea** and **pigeonpea** CWR are not well collected.[201]

Research into regeneration and conservation protocols for wild **chickpea** and **lentil** species is a high priority.[202,203]

Safety duplication

While more information is needed on the extent and location of materials duplicated for safety purposes, it is apparent that many important collections are inadequately duplicated and are thus at risk.[204]

It is apparent that many important **lentil**, **faba bean**, **chickpea**, **grasspea** collections are inadequately duplicated and are thus at risk. Safety duplication requires a formal arrangement. The fact that an accession is present in another collection does not immediately signify that the accession is safety duplicated in long-term conservation conditions. At a minimum all unique materials should be duplicated for safety reasons, preferably in a second country. Depositions of safety backup samples with the Svalbard Global Seed Vault is underway, especially by the global collections (e.g., those at ICARDA and ICRISAT).[205,206,207,208]

Documentation, characterization, evaluation

Some **chickpea** and **lentil** databases are not yet internet accessible, a global registry for each and documentation training are needed. Only a minority of **grasspea** databases are internet accessible, but there is a *Lathyrus* global information system managed by Bioversity and ICARDA.[209]

Many **chickpea** and **lentil** accessions are not yet characterized or evaluated and little of the data that are available is electronically accessible.[210,211]

Information currently held on ***Vicia faba*** accessions in collections is often fragmented and not easily accessible outside of the institution, and genebank information systems generally need strengthening. Technical advice for information systems is needed.[212]

Utilization

Chickpea CWR have been sources of resistance used in breeding programs. **Lentil** CWR have been used in breeding programs to broaden the genetic base and provide genes for tolerance and resistance. **Pigeonpea** CWR are sources of resistance and protein.[213]

Lentil, **faba bean**, and **chickpea** genetic resources are under-utilized due to deficiencies in accession level data; suboptimal availability and accessibility of that data; lack of pre-breeding, core-collection creation, and other 'value-adding' work in genebanks; and few collaborative relationships with user communities.[214,215,216]

Almost all national collections of **faba beans** appear to be distributing almost entirely to domestic users.[217]

Higher and more stable yields are key breeding objectives for **chickpea**. Some of the wild relatives have been utilized in breeding programs and resistance to abiotic and biotic stresses have been incorporated into the crop from *Cicer reticulatum* and *C. echinospermum*, chickpea's closest relatives.[218]

Breeding for higher and more stable yields–the latter through enhanced resistance to pests and diseases–are thus major breeding objectives.[219]

Constraints in **chickpea** and **lentil** germplasm utilization are deficient data (and data access) about accessions, lack of pre-breeding, and collaborative relationships. Similarly, lack of accession information is a constraint for **grasspea** germplasm. For **pigeonpea** germplasm, constraints include inadequate accession data, difficulty in use of CWR, genetic contamination in collections, absence of pest and disease resistance traits, and poor interaction between breeders and conservers.[220]

Regeneration of perennial **chickpea** CWR accessions would enhance their utilization.[221]

There are relatively few efforts throughout the world to genetically improve **grasspea**, there are some important programs that aim to improve its yield, resistance to biotic and abiotic stresses and, most importantly, to reduce the percentage, or ideally eliminate, the neurotoxin from the seed. However, local landraces and cultivars are being lost as farmers switch to alternative crops—potentially limiting the progress that can be made through genetic enhancement.[222]

Role of crop in sustainable production systems and organic production systems

Chickpea is grown and consumed in large quantities from South East Asia across the Indian sub-continent, and throughout the Middle East and Mediterranean countries, playing an important cultural as well as nutritional role. Over 95% of the area, production, and consumption of **chickpea** takes place in developing countries. The crop meets up to 80% of its nitrogen requirement from symbiotic nitrogen fixation and can fix up to 140 kg nitrogen per hectare per season from the air.[223]

Lentil plants provide a number of functions aside from being sources of human food. Lentil straw is an important fodder for small ruminants in the Middle East and North Africa, and the nitrogen sequestrating plant improves soil fertility and therefore increases sustainability of agricultural production systems.[224]

Because of the extreme tolerance of **grasspea** to difficult environmental conditions, including both drought and water-logging, it often survives when other crops are decimated. However, in years when conditions are particularly harsh, human consumption of this survival food may increase—through lack of any suitable alternative, especially for the poorest rural people—to a level at which there is a severe risk of the consumer succumbing to a neurological disorder, lathyrism, caused by the presence of a neurotoxin in the seed. The toxicity results in irreversible paralysis, characterized by lack of strength in, or inability to move the lower limbs. It is particularly prevalent in some areas of Bangladesh, Ethiopia, India, and Nepal, and affects more men than women.[225]

Grasspea is important locally for the poorest of the poor in many of the harshest agro-environments—especially in South Asia and Ethiopia.[226]

A4.3.4 State of grape genetic resources

Since 1995, the yield of grapes (*Vitis*) has increased overall, with a slight drop in 2001 and rebound in 2004 (see Fig. A4.5). Grapes were grown in 2007 over a harvested area of 7 million hectares with global production of 67 million tonnes.[227] The five largest producers of grapes in 2007 were Italy (13% of global production), China (10%), and USA, France, and Spain (9% each).

In situ *conservation status*

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

Ex situ *conservation status*

Approximately 59,500 accessions of *Vitis* are held in the world's genebanks. No one collection stands out as the largest. The top six each hold between 9 and 4% of the total accessions.[228]

Field collections have been established for the 70 most important autochthonous grapevine cultivars (Portugal Country Report).

Genetic erosion and vulnerability

Traditional grapevine varieties are still used. However the number of varieties used at a large scale has been substantially reduced (Greece Country Report). The traditional grapevine crop is threatened by genetic erosion (Portugal Country Report).

A4.3.5 State of tree nut genetic resources

Since 1995, the yield of tree nuts has been essentially constant (see Fig. A4.5). Tree nuts[229] were grown in 2007 over a harvested area of 9 million hectares with global production of 11 million tonnes.[230] The six largest producers in 2007 were China and USA (each with 15% of global production), Viet Nam (11%), Turkey (8%), and Nigeria and India (6% each). China produced the most diverse assemblage of this large group of tree nuts with 6 out of 8 of them, USA, Italy, and Turkey each produced 5, and Iran and Pakistan each produced 4.

Genetic erosion and vulnerability

Wild almond trees are under threat due to the replacement by new varieties (Georgia Country Report).

In the Beka'a Valley, all commercial almond orchards consist of one or two early-blooming varieties, thus susceptible to spring frost, explaining the observed decrease in national almond production in certain years (Lebanon Country Report).

A4.3.6 State of vegetable and melon genetic resources

The yield of vegetables and melons has increased slightly (see Fig. A4.5). Vegetables and melons[231] were grown in 2007 over a harvested area of 53 million hectares with global production of 900 million tonnes.[232] The six largest producers in 2007 were China (50% of global production), India (8%), USA (4%), Turkey (3%), and the Russian Federation, Iran, and Egypt (2% each). China produced the most diverse assemblage of this large group of vegetables and melons with 24 out of 25 of them, USA produced 23, Turkey, Spain, and Mexico produced 20 each, Japan produced 19, and Italy produced 18.

Genetic erosion and vulnerability

A diversity of countries reported instances of concern for diversity of several different vegetables:

- Several vegetable crops (carrot, turnip, eggplant, onion, and cauliflower) are at risk from new commercial varieties (Madagascar Country Report).
- There is loss of diversity in vegetables crops (Trinidad and Tobago Country Report).
- There is gradual disappearance of landraces of cabbage and cauliflower (Nepal Country Report).
- Due to market demand and unavailability of local seeds, the rate of genetic erosion has been very high in major vegetables like tomatoes, onions, peas, okra, brinjal (eggplant), cauliflower, carrots, radish, and turnips. Indigenous diversity is still found in cucurbits, bitter gourd, spinach, lufa, and species of *Brassica*. The genetic resources of indigenous underutilized minor-crop species face rapid destruction owing to erosion of traditional farming culture, change of traditional food habits, and introduction of high yielding crops (Pakistan Country Report).
- There is genetic erosion in eggplant, bitter gourd, sponge gourd, bottle gourd, and tomato (Philippines Country Report).
- Due to importing new varieties and hybrids and lack of seeds of local varieties, the rate of genetic erosion has been very high in major vegetables like cucumbers, tomatoes, onions, cabbage, carrots, radish, black radish, turnips, etc. (Tajikistan Country Report).
- Genetic erosion in vegetable crops, because of replacement of local germplasm by modern varieties, has been 15 to 20 years behind the rate in cereals, however, in recent

years, local landraces are being rapidly displaced even from backyard gardens (Greece Country Report).

- Commercial horticultural production is dominated by imported modern high-yielding varieties, little or no landraces or farmers' varieties are grown. In contrast, great diversity in horticulture crops is found in the various private gardens around the nation in the form of home-saved seed (Ireland Country Report).

1 Text of the treaty with Annex 1 is at http://www.planttreaty.org/texts_en.htm

2 In addition to the chapters of this second SoW report and the contributed country reports, other sources for the information for this annex were FAO crop production statistics (latest data available were for 2007) and food balance sheets (both available at FAOSTAT: http://faostat.fao.org/), the crop conservation strategy documents produced by the Global Crop Diversity Trust (http://www.croptrust.org/), and the scientific literature. The ratio of the FAOSTAT production tonnages and cultivated areas were calculated for the figures showing the trends between 1996 and 2007 and rounded to the nearest million tonnes/hectares.

3 A conclusion reported in Chapter 3 based on an analysis of records and reports from international, regional, and national collections.

4 **Maxted, N. and Kell, S.P.** 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.

5 **Swiderska, K.** 2009. Seed industry ignores farmers' rights to adapt to climate change. Press release 07/09/2009. International Institute for Environment and Development London, UK. http://www.iied.org/natural-resources/key-issues/biodiversity-and-conservation/seed-industry-ignores-farmers%E2%80%99-rights-adapt-climate-change

6 For example, Country Reports of Albania, Armenia, Bangladesh, Cameroon, Chile, Cook Islands, Costa Rica, Croatia, Cyprus, Dominican Republic, Egypt, Ethiopia, Georgia, Ghana, Greece, Guinea, Italy, Jordan, Kazakhstan, Kenya, Lao PDR, Lebanon, Malaysia, Malawi, Mexico, Nepal, Nicaragua, Oman, Peru, Philippines, Portugal, Romania, Slovak Republic, Tajikistan, Tanzania, Thailand, Togo, Uruguay, Venezuela, Viet Nam, Zambia, and more.

7 See the Global Crop Diversity Trust's website for its full history and mission. http://www.croptrust.org/

8 **GCDT.** 2008. Annual report 2008. Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/WebPDF/TrustAnnualReport2008Final.pdf

9 The CWR Global Portal is at http://www.cropwildrelatives.org/index.php?page=about

10 For example, Country Reports of Algeria, Armenia, Bolivia, Bosnia Herzegovina, Ethiopia, Ireland, Italy, Lao PDR, Madagascar, Norway, Oman, Poland, Sri Lanka, Switzerland, Uzbekistan, Viet Nam, and more.

11 Documented in the GCDT crop strategies and Country Reports and summarized in Chapter 3.

12 **Khoury, 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. Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/WebPDF/Crop%20and%20Regional%20Conservation%20Strategies%20Review1.pdf

13 Ibid. note 12.

14 http://www.ipcc.ch

15 **Dulloo, M.E., Labokas, J., Iriondo, J.M., Maxted, N., Lane, A., Laguna,E., Jarvis, A. and Kell, S.P.** 2008. Genetic reserve location and design. p.23-64 *in* J. Iriondo, N. Maxted, and M.E. Dulloo (eds.) *Conserving plant genetic diversity in protected areas*. CAB International. Wallingford, UK.

16 **UN FAOSTAT.** 2007. Agricultural Production Domain http://faostat.fao.org/site/339/default.aspx

17 Ibid. note 16.

18 **GCDT.** 2007. Global strategy for the *ex situ* conservation with enhanced access to wheat, rye, and triticale genetic resources. Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/Wheat-Strategy-FINAL-20Sep07.pdf

19 Ibid. note 18.

20 Ibid. note 18; Ibid. note 12.

21 Armenia Country Report

22 Appendix 2 List of major germplasm accessions by crop and institute. The figure reported includes *Triticum*, *Aegilops* and *x Triticosecale* accessions.

23 Ibid. note 18; Ibid. note 12.

24 Ibid. note 18.

25 Ibid. note 12.

26 Ibid. note 18; Ibid. note 12.

27 Ibid. note 16.

28 **Vaughan, D.A. and Morishima, H.** 2003. Biosystematics of the genus Oryza. p. 27-65 *in* C.W. Smith and R.H. Dilday (eds.) *Rice: Origin, History, Technology, and Production*. John Wiley & Sons, Inc. Hoboken NJ USA.

29 Ibid. note 12.

30 Ibid. note 12.

[31] Ibid. note 12.
[32] Ibid. note 12.
[33] Ibid. note 16.
[34] **GCDT.** 2007. Global strategy for the *ex situ* conservation and utilization of maize germplasm. Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/Maize-Strategy-FINAL-18Sept07.pdf
[35] Ibid. note 34.
[36] Ibid. note 34.
[37] Ibid. note 12.
[38] Ibid. note 34.
[39] Ibid. note 34.
[40] Ibid. note 34.
[41] Ibid. note 34.
[42] Ibid. note 34.
[43] Ibid. note 12.
[44] Ibid. note 12.
[45] Ibid. note 34.
[46] Ibid. note 12.
[47] Ibid. note 34.
[48] Ibid. note 12.
[49] Ibid. note 34.
[50] Ibid. note 34.
[51] Ibid. note 12.
[52] Ibid. note 34.
[53] Ibid. note 12.
[54] Ibid. note 34.
[55] Ibid. note 34.
[56] Ibid. note 34.
[57] Ibid. note 16.
[58] For a review and discussion of the taxonomic situation in *Sorghum*, see Dahlberg, J.A. 2000. Classification and characterization of *Sorghum*. p. 99-259 *in* C.W. Smith and R.A. Frederiksen (eds.) *Sorghum: Origin, History, Technology, and Production*. John Wiley & Sons, Inc. Hoboken NJ USA.
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[62] Ibid. note 59.
[63] Ibid. note 12.
[64] Ibid. note 59.
[65] Ibid. note 59.
[66] Ibid. note 12.
[67] Ibid. note 12.
[68] Ibid. note 59.
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[70] Ibid. note 59.
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[77] Ibid. note 12.
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[79] Ibid. note 60.
[80] **WIEWS.** 2009. http://apps3.fao.org/wiews
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[111] Ibid. note 109.
[112] Ibid. note 12.
[113] Ibid. note 12.
[114] Ibid. note 109.
[115] Ibid. note 12.
[116] Ibid. note 12.
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[143] Ibid. note 12.

[144] Ibid. note 138.

[145] Ibid. note 138.

[146] Ibid. note 12.

[147] Ibid. note 138.

[148] Ibid. note 138.

[149] Ibid. note 12.

[150] Ibid. note 138.

[151] Ibid. note 138.

[152] Ibid. note 16.

[153] Ibid. note 16.

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[156] Taro, yam, yautia, and roots and tubers not elsewhere counted.

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[165] Ibid. note 12.

[166] Ibid. note 158.

[167] Ibid. note 158.

[168] Ibid. note 12.

[169] Ibid. note 158.

[170] Ibid. note 12.

[171] Ibid. note 158.

[172] Ibid. note 158.

[173] Ibid. note 158.
[174] Bambara bean, broad or horse bean, chickpea, cowpea, lentil, lupin, pea (dry), pigeon pea, vetch, and other pulses not elsewhere counted.
[175] Ibid. note 16.
[176] **GCDT.** 2008. Global strategy for the ex situ conservation of lentil (*Lens* Miller). Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/LensStrategy_FINAL_3Dec08.pdf
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[178] **GCDT.** 2008. Global strategy for the *ex situ* conservation of chickpea (*Cicer* L.). Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/CicerStrategy_FINAL_2Dec08.pdf
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[181] Ibid. note 180.
[182] **GCDT.** 2007. Strategy for the *ex situ* conservation of *Lathyrus* (grass pea), with special reference to *Lathyrus sativus, L. cicera*, *L. ochrus.* Global Crop Diversity Trust. Rome, Italy. http://www.croptrust.org/documents/web/Lathyrus-Strategy-FINAL-31Oct07.pdf
[183] Ibid. note 178.
[184] Ibid. note 180.
[185] Ibid. note 80.
[186] Ibid. note 80.
[187] Ibid. note 80.
[188] Ibid. note 80.
[189] Ibid. note 80.
[190] Ibid. note 176.
[190] Ibid. note 180.
[192] Ibid. note 178.
[193] Ibid. note 182.
[194] Ibid. note 176.
[195] Ibid. note 180.
[196] Ibid. note 178.
[197] Ibid. note 182.
[198] Ibid. note 12.
[199] Ibid. note 176.
[200] Ibid. note 178.
[201] Ibid. note 12.
[202] Ibid. note 178.
[203] Ibid. note 176.
[204] Ibid. note 176.
[205] Ibid. note 176.
[206] Ibid. note 180.
[207] Ibid. note 178.
[208] Ibid. note 182.
[209] Ibid. note 12.
[210] Ibid. note 178.
[211] Ibid. note 176.
[212] Ibid. note 180.
[213] Ibid. note 12.
[214] Ibid. note 178.
[215] Ibid. note 180.
[216] Ibid. note 176.
[217] Ibid. note 180.
[218] Ibid. note 178.
[219] Ibid. note 178.
[220] Ibid. note 12.
[221] Ibid. note 12.

[222] Ibid. note 182.
[223] Ibid. note 178.
[224] Ibid. note 176.
[225] Ibid. note 182.
[226] Ibid. note 182.
[227] Ibid. note 16.
[228] Ibid. note 121.
[229] Almond, Brazil nut, cashew, chestnut, hazelnut, pistachio, walnut, and nuts not elsewhere counted.
[230] Ibid. note 16.
[231] Artichokes, asparagus, beans (green), cabbages, carrots and turnips, cauliflower and broccolis, chillies and peppers (green), cucumbers and gherkins, eggplants, garlic, leguminous vegetables not elsewhere counted, lettuce and chicory, maize (green), mushrooms, okra, onions (green), onions (dry), cantaloupes and other melons, peas (green), pumpkins and squash, spinach, beans (string), tomatoes, fresh vegetables not elsewhere counted, and watermelons.
[232] Ibid. note 16.

Acronyms and abbreviations

AARI	Aegean Agricultural Research Institute of Turkey
AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
ABI	Institute for Agrobotany (Hungary)
ABS	Access and benefit-sharing
ACCI	African Centre for Crop Improvement
ACIAR	Australian Centre for International Agricultural Research
ACSAD	Arab Center for the Study of Arid Zones and Dry Lands
AD-KU	Department of Agronomy, Faculty of Agriculture, University of Kasetsart (Thailand)
AEGIS	European Genebank Integrated System
AFLP	Amplified Fragment-Length Polymorphism
AGRESEARCH	Margot Forde Forage Germplasm Centre, Agriculture Research Institute Ltd (New Zealand)
AICRP-Cashew	All India Coordinated Project on Cashew (India)
AICRP-Soybean	All India Coordinated Research Project on Soybean (India)
AMFO	G.I.E. Amelioration Fourragère (France)
AMGRC	Australian Medicago Genetic Resource Centre, South Australian Research and Development Institute
ANGOC	Asian NGO Coalition for Agrarian Reform and Rural Development
AOAD	Arab Organization for Agricultural Development
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ARC (LBY001)	Agricultural Research Centre (Libyan Arab Jamahiriya)
ARC (SDN001)	Plant Breeding Section, Agricultural Research Corporation (Sudan)
AREO	Agricultural Research and Education Organization (Iran)
ARI (CYP004)	National (CYPARI) Genebank, Agricultural Research Institute, Ministry of Agriculture, Natural Resources and Environment (Cyprus)
ARI (ALB002)	Agricultural Research Institute (Albania)
ARIPO	African Regional Industrial Property Organization
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASEAN	Association of Southeast Asian Nations

ASN	Africa Seed Network
ASPNET	Asia-Pacific Network
ATCFC	Australian Tropical Crops & Forages Genetic Resources Centre
ATFCC	Australian Temperate Field Crops Collection
AusPGRIS	Australian Plant Genetic Resource Information Service
AVRDC	Asian Vegetable Research and Development Center
AWCC	Australian Winter Cereals Collection
AYR-DPI	Mango Collection, Ayr, Department of Primary Industries (Australia)
BAAFS	Beijing Academy of Agriculture and Forestry Sciences
BAL	Banco Activo de Germoplasma de Papa, Forrajeras y Girasol Silvestre (Argentina)
BAP	Banco Activo de Germoplasma de Pergamino (Argentina)
BAPNET	Banana Asia Pacific Network
BARI	Plant Genetic Resources Centre (Bangladesh)
BARNESA	Banana Research Network for Eastern and Southern Africa
BAZ	Federal Centre of Breeding Research on Cultivated Plants (Braunschweig, Germany)
BB	Banana Board (Jamaica)
BBC-INTA	Banco Base de Germoplasma, Instituto de Recursos Biológicos, Instituto Nacional de Tecnología Agropecuaria (Argentina)
BCA	Bunda College of Agriculture (Malawi)
BCCCA	Biscuit, Cake, Chocolate and Confectionery Association
BECA	Biosciences Eastern and Central Africa
BGCI	Botanic Garden Conservation International
BGRI	Borlaug Global Rust Initiative
BGUPV	Generalidad Valenciana, Universidad Politécnica de Valencia. Escuela Técnica Superior de Ingenieros Agrónomos, Banco de Germoplasma (Spain)
BG-VU	Botanical Garden, Vilnius University (Lithuania)
BINA	Bangladesh Institute of Nuclear Agriculture
BJRI	Bangladesh Jute Research Institute
BNGGA-PROINPA	Fundación para la Promoción e Investigación de Productos Andinos, Regional Altiplano (Bolivia)
BNGTRA-PROINPA	Fundación para la Promoción e Investigación de Productos Andinos (Bolivia)
BPGV-DRAEDM	Portuguese Bank of Plant Germplasm
BRDO	Biotechnology Research and Development Office (Thailand)
BRGV Suceava	Suceava Genebank (Romania)

BRRI	Bangladesh Rice Research Institute
BSRI	Bangladesh Sugarcane Research Institute
BTRI	Bangladesh Tea Research Institute
BVRC	Beijing Vegetable Research Centre, Beijing Academy of Agricultural Sciences
BYDG	Botanical Garden of Plant Breeding and Acclimatization Institute (Poland)
CAAS	Chinese Academy of Agricultural Sciences
CABMV	Cowpea Aphid-Borne Mosaic Virus
CACAARI	Central Asia and the Caucasus Association of Agricultural Research Institutions
CacaoNet	Global Cacao Genetic Resources Network
CACN-PGR	Central Asian and Caucasian Network on Plant Genetic Resources
CAPGERNET	Caribbean Plant Genetic Resources Network
CARBAP	Centre Africain de Recherches sur Bananiers et Plantains
CARDI	Caribbean Agricultural Research and Development Institute
CAS-IP	Central Advisory Service on Intellectual Property
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (Costa Rica)
CBD	Convention on Biological Diversity
CBDC	Community Biodiversity Development Conservation
CBG	Central Botanical Garden (Azerbaijan)
CBICAU	Crop Breeding Institute (Zimbabwe)
CBNA	Conservatoire Botanique National Alpin de Gap-Charance (France)
CC	Cartón de Colombia S.A. (Colombia)
CC-IASP	Centro de Citrocultura «Sylvio Moreira», Instituto Agronomico de São Paulo (Brazil)
CCRI	Central Cotton Research Institute, Multan (Pakistan)
CEARD	Centre of Excellence for Agrobiodiversity Resources and Development of China
CENARGEN	Embrapa Recursos Genéticos e Biotecnologia (Brazil)
CENICAFE	Centro Nacional de Investigaciones de Café “Pedro Uribe Mejia”, Federación Nacional de Cafeteros de Colombia (Colombia)
CePaCT	Centre for Pacific Crops and Trees
CEPEC	Centro de Pesquisa do Cacao (Brazil)
CERI	Cereal Institute, National Agricultural Research Foundation (Greece)
CGIAR	Consultative Group on International Agricultural Research

CGN	Centre for Genetic Resources, the Netherlands Plant Research International (Netherlands)
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIAT	Centro Internacional de Agricultura Tropical
CICR	Central Institute for Cotton Research (India)
CIFACOR	Junta de Andalucía, Instituto Andaluz de Investigación Agroalimentaria y Pesquera, Centro de Investigación y Formación Agroalimentaria Córdoba (Spain)
CIFAP-CAL	Centro de Investigaciones Forestales y Agropecuarias, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
CIFP	Centro de Investigaciones Fitoecogenéticas de Pairumani (Bolivia)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CIP	Centro Internacional de la Papa
Cirad	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
CIS	Commonwealth of Independent States
CISH	Central Institute for Subtropical Horticulture (India)
CITH	Central Institute of Temperate Horticulture (India)
CLAN	Cereal and Legume Asia Network
CLAYUCA	Latin American/Caribbean Consortium on Cassava Research and Development
CN	Centre Néerlandais (Côte d'Ivoire)
CNPA	Embrapa Algodão (Brazil)
CNPAF	Embrapa Arroz e Feijão (Brazil)
CNPAT	Embrapa Agroindústria Tropical (Brazil)
CNPF	Embrapa Florestas (Brazil)
CNPGC	Embrapa Gado de Corte (Brazil)
CNPH	Embrapa Hortaliças (Brazil)
CNPMF	Embrapa Mandioca e Fruticultura Tropical (Brazil)
CNPMS	Embrapa Milho e Sorgo (Brazil)
CNPq	National Council for Scientific and Technological Development of Brazil
CNPSO	Embrapa Soja (Brazil)
CNPT	Embrapa Trigo (Brazil)
CNPUV	Embrapa Uva e Vinho (Brazil)
CNRRI	China National Rice Research Institute
COILLTE	Coillte Teoranta, The Irish Forestry Board (Ireland)
CONSEFORH	Proyecto de Conservación y Silvicultura de Especies Forestales de Honduras
COP	Conference of the Parties to the Convention on Biological Diversity

COPAL	Cocoa Producers Alliance
COR	National Clonal Germplasm Repository, United States Department of Agriculture, Agricultural Research Services (United States)
CORBANA	Corporación Bananera Nacional S.A. (Costa Rica)
CORPOICA	Centro de Investigación La Selva, Corporación Colombiana de Investigación Agropecuaria (Colombia)
CORRA	Council for Partnerships on Rice Research in Asia
COT	Crop Germplasm Research Unit United States Department of Agriculture, Agricultural Research Services (United States)
CPAA	Embrapa Amazônia Ocidental (Brazil)
CPACT/EMBRAPA	Embrapa Clima Temperado (Brazil)
CPATSA	Embrapa Semi-Árido (Brazil)
CPBBD	Central Plant Breeding and Biotechnology Division, Nepal Agricultural Research Council (Nepal)
CPRI	Central Potato Research Institute (India)
CRA-CAT	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Unità di Ricerca per le Colture alternative al Tabacco (Italy)
CRA-FLC	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per le Produzioni Foraggere e Lattiero-Casearie (Italy)
CRA-FRF	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Unitá di Ricerca per la Frutticoltura (Italy)
CRA-FRU	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per la Frutticoltura (Italy)
CRAGXPP	Département de Lutte Biologique et Ressources Phytogénétiques, Centre de Recherches Agronomiques de Gembloux, Ministere des Classes Moyennes et de l'Agriculture (Belgium)
CRA-OLI	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per l'Olivicoltura e l'Industria Olearia (Italy)
CRA-VIT	Consiglio per la Ricerca e la Sperimentazione in Agricoltura - Centro di Ricerca per la Viticoltura (Italy)
CRC	Central Romana Corporation (Dominican Republic)
CRI	Citrus Research Institute, Chinese Academy of Agricultural Sciences (China)
CRIA	Central Research Institute for Agriculture (Indonesia)
CRIG	Cocoa Research Institute of Ghana
CRIN	Cocoa Research Institute of Nigeria

CRU	Cocoa Research Unit, University of the West Indies (Trinidad and Tobago)
CSFRI	Citrus and Subtropical Fruit Research Institute (South Africa)
CSIRO	Commonwealth Scientific & Industrial Research Organization, Division of Horticultural Research
CTA	Centre technique de coopération agricole et rurale
CTC	Centro de Tecnologia Canavieira (Brazil)
CTRI	Central Tobacco Research Institute (India)
CWR	Crop wild relatives
DANAC	Fundación para la Investigación Agrícola DANAC (Venezuela)
DAR	Department of Agricultural Research, Ministry of Agriculture (Botswana)
DAV	National Germplasm Repository, United States Department of Agriculture, Agricultural Research Services, University of California (United States)
DB NRRC	Dale Bumpers National Rice Research Center, United States Department of Agriculture, Agricultural Research Services (United States)
DCRS	Dodo Creek Research Station, Ministry of Home Affairs and Natural Development (Solomon Islands)
DENAREF	Departamento Nacional de Recursos Fitogenéticos y Biotecnología (Ecuador)
DFS	Artemivs'k Experimental Station (Ukraine)
DGCB-UM	Department of Genetics and Cellular Biology, University Malaya (Malaysia)
DLP Laloki	Dry-lowlands Research Programme, Laloki (NARI) (Papua New Guinea)
DNA	Deoxyribonucleic acid
DOA	Department of Agriculture, Papua New Guinea University of Technology (Papua New Guinea)
DOR	Directorate of Oilseeds Research (India)
DPS-MGU	Department of Plant Science, Macdonald Campus of McGill University (Canada)
DTRUFC	División of Tropical Research, United Fruit Company (Honduras)
EA-PGR	Regional Network for Conservation and Use of Plant Genetic Resources in East Asia
EAPGREN	East African Plant Genetic Resources Network
EAPZ	Escuela Agrícola Panamericana El Zamorano (Honduras)
EARTH	Escuela de Agricultura de la Region Tropical Humeda (Costa Rica)

EC	European Community
ECICC	Estación Central de Investigaciones de Café y Cacao (Cuba)
ECOWAS	Economic Community of West African States
ECPGR	European Cooperative Programme for Genetic Resources
EEA INTA Anguil	Estación Experimental Agropecuaria "Ing. Agr. Guillermos Covas" (Argentina)
EEA INTA Bordenave	Estación Experimental Agropecuaria Bordenave (Argentina)
EEA INTA Cerro Azul	Estación Experimental Agropecuaria Cerro Azul (Argentina)
EENP	Estación Experimental Napo-Payamino (Ecuador)
EETP	Estación Experimental Pichilingue (Ecuador)
EFOPP	Enterprise for Extension and Research in Fruit Growing and Ornamentals (Hungary)
EMBRAPA	Brazilian Agricultural Research Corporation
ENSCONET	European Native Seed Conservation Network
ePIC	Electronic Plant Information Centre (United Kingdom)
ESA	Environmentally Sensitive Areas
ESCORENA	European System of Cooperative Research Networks on Agriculture
ETC	Group Action Group on Erosion, Technology and Concentration
EU	European Union
EUFORGEN	European Forest Genetic Resources Network
EURISCO	European Internet Search Catalogue
EWS R&D	East West Seed Research and Development Division (Bangladesh)
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistical Database
FARA	Forum for Agricultural Research in Africa
FAST	Faculté des Sciences et Techniques (Benin)
FA-UDELAR	Facultad de Agronomía (Uruguay)
FCRI	Food Crops Research Institute (Viet Nam)
FCRI-DA	Field Crops Research Institute – Department of Agriculture (Thailand)
FF.CC.AA.	Facultad de Ciencias Agrarias (Peru)
FHIA	Honduran agricultural research foundation
FIGS	Focused Identification of Germplasm Strategy
FONTAGRO	Regional Forum for Agricultural Research and Technology Development
FORAGRO	Forum for the Americas on Agricultural Research and Technology Development
FPC	Firestone Plantations Company (Liberia)

FRIM	Forest Research Institute of Malaysia
FRUCTUS	FRUCTUS, Association Suisse pour la Sauvegarde du Patrimoine Fruitier (Switzerland)
GBREMR	East Malling Research (United Kingdom)
GBWS	Germplasm Bank of Wild Species (China)
GCDT	Global Crop Diversity Trust
GCP	Generation Challenge Programme
GEF	Global Environment Facility
GEN	Plant Genetic Resources Unit, Cornell University, New York State Agricultural Experiment Station, United States Department of Agriculture, Agricultural Research Services (United States)
GEVES Angeres	Unité Expérimentale d'Angers, Groupe d'Étude et de contrôle des Variétés et des Semences
GEVES Sophia-Antiopolis	Unité Expérimentale de Sophia-Antipolis, Groupe d'Étude et de contrôle des Variétés et des Semences (France)
GFAR	Global Forum on Agricultural Research
GIPB	Global Partnership Initiative for Plant Breeding Capacity Building
GIS	Geographic Information System
GM	Genetically modified
GMO	Genetically modified organisms
GMZ	Gene Management Zones
GPA	Global Plan of Action for the Conservation and Utilization of PGRFA
GPRI	Genetic Resources Policy Initiative of Biodiversity International
GPS	Global Positioning Systems
GRENEWECA	Genetic Resources Network for West and Central Africa
GRI	Genetic Resources Institute (Azerbaijan)
GRIN	Germplasm Resources Information Network
GSC	Guyana Sugar Corporation, Breeding and Selection Department (Guyana)
GSLY	Tomato Genetic Stock Center
GSPC	Global Strategy for Plant Conservation
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HBROD	Potato Research Institute Havlickuv Brod Ltd. (Czech Republic)
HOLOVOU	Research and Breeding Institute of Pomology, Holovousy Ltd. (Czech Republic)
HRC, MARDI	Horticulture Research Centre, Malaysian Agricultural Research and Development Institute (Malaysia)

HRI-DA/THA	Horticultural Research Institute, Department of Agriculture (Thailand)
HRIGRU	Horticultural Research International, University of Warwick, Genetic Resources Unit (United Kingdom)
HSCRI	Horticulture and Subtropical Crops Research Institute (Azerbaijan)
IAC	Instituto Agronómico de Campinas (Brazil)
IAO	Istituto Agronomico per l'Oltremare
IAPAR	Area de Documentação, Instituto Agronomico do Paraná (Brazil)
IARC	International Agricultural Research Centre
IARI	Indian Agricultural Research Institute
IBC	Institute of Biodiversity Conservation (Ethiopia)
IBERS-GRU	Genetic Resources Unit, Institute of Biological, Environmental & Rural Sciences, Aberystwyth University (United Kingdom)
IBN-DLO	Institute for Forestry and Nature Research (Netherlands)
IBONE	Instituto de Botánica del Nordeste, Universidad Nacional de Nordeste, Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina)
IBOT	Jardim Botânico (Brazil)
IBPGR	International Board for Plant Genetic Resources
ICA/REGION 1	Corporación Colombiana de Investigación Agropecuaria Tibaitata, CORPOICA (Colombia)
ICA/REGION 5 El Mira	Centro de Investigación El Mira, Instituto Colombiano Agropecuario (Colombia)
ICA/REGION 5 Palmira	Centro de Investigaciones de Palmira, Instituto Colombiano Agropecuario (Colombia)
ICABIOGRAD	Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Centre for Biosaline Agriculture
ICCI-TELAVUN	Lieberman Germplasm Bank, Institute for Cereal Crops Improvement, Tel-Aviv University (Israel)
ICCO	International Cocoa Organization
ICCPT Fundul	Research Institute for Cereals and Technical Plants Fundulea (Romania)
ICG	Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore
ICGN	International Coffee Genome Network

ICGR	Institute of Crop Germplasm Resources (China)
ICGR-CAAS	Institute of Crop Germplasm Resources, Chinese Academy of Agricultural Sciences (China)
ICGT	International Cocoa Genebank (Trinidad)
ICPP Pitesti	Fruit Growing Research Institute Maracineni-Arges (Romania)
ICRAF	International Centre for Research in Agroforestry (now the World Agroforestry Center)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICRR	Indonesian Center for Rice Research
ICVV Valea C	Wine Growing Research Institute Valea Calugareasca-Prahova (Romania)
IDB	Inter-American Development Bank
IDEFOR	Institut pour le Développement des Forêts (Côte d'Ivoire)
IDEFOR-DCC	Département du Café et du Cacao, Institut pour le Développement des Forêts (Côte d'Ivoire)
IDEFOR-DPL	Département des Plantes à Latex, Institut pour le Développement des Forêts (Côte d'Ivoire)
IDESSA	Direction Institut des Savanes (Côte d'Ivoire)
IDI	International Dambala (Winged Bean) Institute (Sri Lanka)
IDRC	International Development Research Centre
IFAD	International Fund for Agricultural Development
IFAP	International Federation of Agricultural Producers
IFS	International Foundation for Science
IFVCNS	Institute for Field and Vegetable Crops (Serbia)
IGB	Israel Gene Bank for Agricultural Crops, Agricultural Research Organisation, Volcani Center
IGFRI	Indian Grassland and Fodder Research Institute
IGV	Istituto di Genetica Vegetale, Consiglio Nazionale delle Richerche (Italy)
IHAR	Plant Breeding and Acclimatization Institute (Poland)
IICA	Inter-American Institute for Cooperation on Agriculture
IIT	Instituto de Investigaciones del Tabaco
IITA	International Institute of Tropical Agriculture
ILETRI	Indonesian Legume and Tuber Crops Research Institute
ILK	Institute of Bast Crops (Ukraine)
ILRI	International Livestock Research Institute
IMIACM	Comunidad de Madrid, Dirección General de Agricultura y Desarrollo Rural, Instituto Madrileño de Investigación Agraria y Alimentaria (Spain)
INBAR	International Network for Bamboo and Rattan

INCANA	Inter-regional Network on Cotton in Asia and North Africa
INCORD	Cotton Institute for Research and Development (Viet Nam)
INERA	Institut National pour l'Etude et la Recherche Agronomique (Congo)
INGENIC	International Group for the Genetic Improvement of Cocoa
INGER	International Network for the Genetic Evaluation of Rice
INIA-CENIAP	Centro Nacional de Investigaciones Agropecuarias, Instituto Nacional de Investigaciones Agrícolas (Venezuela)
INIA CARI	Centro Regional de Investigación, Instituto Nacional de Investigaciones Agrícolas, Carillanca (Chile)
INIA INTIH	Banco Base, Instituto de Investigaciones Agropecuarias, Intihuasi (Chile)
INIA QUIL	Centro Regional de Investigación, Instituto de Investigaciones Agropecuarias, Quilamapu (Chile)
INIACRF	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Centro de Recursos Fitogenéticos (Spain)
INIA-EEA.ILL	Estación Experimental Agraria, Illpa (Peru)
INIA-EEA.POV	Estación Experimental Agraria, El Porvenir (Peru)
INIAFOR	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Centro de Investigaciones Forestales (Spain)
INIA-Igual	Estación de Iguala, Instituto Nacional de Investigaciones Agrícolas (Mexico)
INIAP/DENAREF	Instituto Nacional de Tecnología Agropecuaria, Department of Plant Genetic Resources
INIBAP	International Network for the Improvement of Banana and Plantain, Musa Germplasm Transit Centre, Catholic University Leuven
INICA	Instituto Nacional de Investigación de la Caña de Azúcar (Cuba)
INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
INRA	Institut national de la recherche agronomique (France)
INRA/CRRAS	Institut national de la recherche agronomique/Centre Régional de la Recherche Agronomique de Settat (Morocco)
INRA/ENSA-M	Institut national de la recherche agronomique/Station de Recherches Viticoles (France)

INRA-ANGERS	Institut national de la recherche agronomique/Station d'Amélioration des Espèces Fruitières et Ornementales, (France)
INRA BORDEAUX (FRA057)	Unité de Recherches sur Espèces Fruitières et Vigne, INRA-Bordeaux
INRA BORDEAUX (FRA219)	Institut national de la recherche agronomique/Recherches Forestières (France)
INRA-CLERMONT	Institut national de la recherche agronomique/Station d'Amélioration des Plantes (France)
INRA-DIJON	Institut national de la recherche agronomique/Station de Génétique et d'Amélioration des Plantes (France)
INRA-MONTPELLIER	Institut national de la recherche agronomique/Genetics and Plant Breeding Station, ESRA-INRA SGAP (France)
INRA-POITOU	Institut national de la recherche agronomique/Station d'Amélioration des Plantes Fourragères (France)
INRA-RENNES (FRA010)	Institut national de la recherche agronomique/Station d'Amélioration des Plantes (France)
INRA-RENNES (FRA179)	Institut national de la recherche agronomique/Station d'Amélioration Pomme de Terre et Plantes à Bulbes (France)
INRA-UGAFL	Institut national de la recherche agronomique/Unité de Génétique et Amélioration des Fruits et Légumes (France)
INRA-VERSAILLES	Institut national de la recherche agronomique/Station de Génétique/Amélioration des Plantes (France)
INRENARE	Instituto Nacional de Recursos Naturales Renovables (Panama)
IOB	Institute of Vegetable and Melon Growing (Ukraine)
IOPRI	Indonesian Palm Oil Research Institute
IP	Intellectual property
IPB-UPLB	Institute of Plant Breeding, College of Agriculture, University of the Philippines, Los Baños College (Philippines)
IPCC	Intergovernmental Panel on Climate Change
IPEN	International Plant Exchange Network
IPGR	Institute for Plant Genetic Resources «K.Malkov» (Bulgaria)
IPGRI	International Plant Genetic Resources Institute
IPK (DEU271)	External Branch North of the Department Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research, Oil Plants and Fodder Crops in Malchow (Germany)

IPK (DEU159)	External Branch North of the Department Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research, Potato Collection in Gross-Luesewitz (Germany)
IPK (DEU146)	Genebank, Leibniz Institute of Plant Genetics and Crop Plant Research (Germany)
IPPC	International Plant Protection Convention
IPR	Intellectual property rights
IPRBON	Potato Research Institute (Poland)
IPSR	Department of Applied Genetics, John Innes Centre, Norwich Research Park (United Kingdom)
IR	Institute of Plant Production n.a. V.Y. Yurjev of UAAS (Ukraine)
IRCC/CIRAD	Institut de Recherches du Café et du Cacao et autres Plantes Stimulantes/Centre de Coopération Internationale en Recherche Agronomique pour le Développement (Côte d'Ivoire)
IRCT/CIRAD	Département des Cultures Annuelles/Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)
IRRI	International Rice Research Institute
IRTAMB	Generalitat de Catalunya, Institut de Recerca i Tecnologia Agroalimentàries, Centre Mas Bové (Spain)
ISAR	Institut des Sciences Agronomiques du Rwanda
ISF	International Seed Federation
ISFP	Initiative on Soaring Food Prices
ISRA-URCI	Institut Sénégalais de Recherche Agricole-Unité de recherche commune en culture in vitro
IT	Information technology
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
ITRA	Institut Togolais de Recherche Agronomique
IUCN	International Union for the Conservation of Nature
IVM	Institute of Grape and Wine «Maharach» (Ukraine)
JARC	Jimma Agricultural Research Center (Ethiopia)
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Centre for Agricultural Sciences
JKI (DEU098)	Julius Kühn Institute, Federal Research Centre for Cultivated Plants - Institute for Grapevine Breeding Geilweilerhof (Germany)
JKI (DEU451)	Julius Kühn Institute, Federal Research Centre for Cultivated Plants - Institute of Horticultural Crops and Fruit Breeding (Germany)

JKI	Julius Kühn Institute, Federal Research Centre for Cultivated Plants
KARI	Kenya Agricultural Research Institute
KARI-NGBK	National Genebank of Kenya, Crop Plant Genetic Resources Centre, Muguga (Kenya)
KEFRI	Kenya Forest Research Institute
KLOST	Federal College and Research Institute for Viticulture and Fruit Growing (Austria)
KNAES	Kyushu National Agricultural Experiment Station (Japan)
KPS	Crimean Pomological Station (Ukraine)
KROME	Agricultural Research Institute Kromeriz, Ltd. (Czech Republic)
KST	Crimean Tobacco Experimental Station
LAC	Latin America and the Caribbean
LACNET	Latin America and Caribbean Network
LAREC	Lam Dong Agricultural Research and Experiment Centre (Vietnam)
LBN	National Biological Institute (Indonesia)
LEM/IBEAS	IBEAS, Laboratoire d'Ecologie Moléculaire, Université de Pau (France)
LFS	L'viv Experimental Station of Horticulture (Ukraine)
LIA	Lithuanian Institute of Agriculture
LI-BIRD	Local Initiatives for Biodiversity, Research and Development (Nepal NGO)
Linseed	All India Coordinated Project on Linseed, CSA University of Agriculture & Technology, Kanpur, Uttar Pradesh (India)
LPGPB	Laboratory of Plants Gene Pool and Breeding (Armenia)
LRS	Lethbridge Research Station, Agriculture (Canada)
LUBLIN	Institute of Genetics and Plant Breeding, University of Agriculture (Poland)
MARDI	Malaysian Agricultural Research and Development Institute
MARS	Makoka Agricultural Research Station (Malawi)
MAS	Marker Assisted Selection
MDG	Millennium Development Goal
MEA	Millennium Ecosystem Assessment
MHRP	Main Highlands Research Programme, Aiyura (Papua New Guinea)
MIA	Subtropical Horticultural Research Unit, National Germplasm Repository - Miami, United States Department of Agriculture (United States)

MPOB	Malaysia Palm Oil Board
MRB	Malaysian Rubber Board
MRIZP	Maize Research Institute «Zemun Polje» (Serbia)
MRS	Msekera Research Station (Zambia)
MSBP	Millennium Seed Bank Project
MUSACO	Réseau Musa pour l'Afrique Centrale et Occidentale
MUSALAC	Plantain and Banana Research and Development Network for Latin America and the Caribbean
NA	U.S. National Arboretum, United States Department of Agriculture, Agricultural Research Services, Woody Landscape Plant Germplasm Repository (United States)
NABNET	North Africa Biosciences Network
NAEP	National Agri-Environment Programme (Hungary)
NAKB	Inspection Service for Floriculture and Arboriculture (Netherlands)
NARC (LAO010)	Napok Agricultural Research Center (Lao PDR)
NARC (NPL026)	Nepal Agricultural Research Council
NARS	National Agricultural Research System
NBPGR (IND001)	National Bureau of Plant Genetic Resources (India)
NBPGR (IND064)	Regional Station Jodhpur, National Bureau of Plant Genetic Resources (India)
NBPGR (IND024)	Regional Station Thrissur, National Bureau of Plant Genetic Resources (India)
NC7	North Central Regional Plant Introduction Station, United States Department of Agriculture, Agricultural Research Services (United States)
NCGRCD	National Clonal Germplasm Repository for Citrus & Dates, United States Department of Agriculture, Agricultural Research Services (United States)
NCGRP	National Center for Genetic Resources Preservation (United States)
NE9	Northeast Regional Plant Introduction Station, Plant Genetic Resources Unit, United States Department of Agriculture, Agricultural Research Services, New York State Agricultural Experiment Station, Cornell University (United States)
NEPAD	New Partnership for African Development
NFC	National Fruit Collections, University of Reading (United Kingdom)
NGO	Non-governmental organisation
NGRI	National Grassland Research Institute (Japan)
NIAS	National Institute of Agrobiological Sciences (Japan)
NISM	National Information Sharing Mechanism
NMK	National Museums of Kenya

NORDGEN	Nordic Genetic Resources Centre
NORGEN	Plant Genetic Resources Network for North America
NPGRC	National Plant Genetic Resources Centre (Tanzania)
NPGS	National Plant Germplasm System
NR6	Potato Germplasm Introduction Station, United States Department of Agriculture, Agricultural Research Services (United States)
NRCB	National Research Centre for Banana (India)
NRCOG	National Research Centre for Onion and Garlic (India)
NRCRI	National Root Crops Research Institute (Nigeria)
NSGC	National Small Grains Germplasm Research Facility, United States Department of Agriculture, Agricultural Research Services (United States)
NUC	Njala University College (Sierra Leone)
OAPI	African Intellectual Property Organization
OAU	Organization of African Unity
OECD	Organisation for Economic Co-operation and Development
OPRI	Oil Palm Research Institute (Ghana)
ORSTOM-MONTPELLIER	Laboratoire des Ressources Génétiques et Amélioration des Plantes Tropicales, ORSTOM (France)
OSS Roggwil	Verein Obstsortensammlung Roggwil (Switzerland)
PABRA	Pan-African Bean Research Alliance
PAN	Botanical Garden of the Polish Academy of Sciences (Poland)
PAPGREN	Pacific Agricultural Plant Genetic Resources Network
PBBC	Plant Breeding and Related Biotechnology Capacity assessment
PBR	Plant breeders' rights
PCA-ZRC	Philippine Coconut Authority-Zamboanga Research Center
PCR	Polymerase Chain Reaction
PDO	Protected Designation of Origin
PERUG	Dipartimento di Biologia Applicata, Universitá degli Studi, Perugia (Italy)
PES	Payment for ecosystem services
PG	Pomological Garden (Kazakhstan)
PGR	Plant genetic resources
PGRC	Plant Gene Resources of Canada, Saskatoon Research Centre, Agriculture and Agri-Food Canada (Canada)
PGRC	Plant Genetic Resources Centre (Sri Lanka)
PGRFA	Plant genetic resources for food and agriculture
PGRI	Plant Genetic Resources Institute (Pakistan)
PGR-IZs	Plant Genetic Resources Important Zones

PGRRI	Plant Genetic Resources Research Institute (Ghana)
PHES	Plew Horticultural Experimental Station (Thailand)
PhilRice	Philippine Rice Research Institute
PNP-INIFAP	Programa Nacional de la Papa, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
PotatoGene	Potato Gene Engineering Network
PPB	Paticipatory plant breeding
PRC	Plant Resources Center (Viet Nam)
PRGA	Participatory Research and Gender Analysis
PROCIANDINO	Programa Cooperativo de Innovación Tecnológica Agropecuaria para la Región Andina
PROCICARIBE	Agricultural Science and Technology Networking System
PROCINORTE	Cooperative Program in Agricultural Research and Technology
PROCISUR	Cooperative Program for the Technological Development of the Agro-food and Agro-industry in the Southern Cone
PROCITROPICOS	Programa Cooperativo de Investigación y Transferencia de Tecnología para los Trópicos Suramericanos
PRUHON	Research Institute of Landscaping and Ornamental Gardening (Czech Republic)
PSR	Pro Specie Rara (Switzerland)
PU	Peradeniya University (Sri Lanka)
PULT	Department of Special Crops (Tobacco), Institute Soil Science and Plant Cultivation (Poland)
PVP	Plant variety protection
QDPI	Queensland Department of Primary Industries, Maroochy Research Station (Australia)
QPM	Quality protein maize
QTL	Quantitative trait locus
RAC (CHE019)	Domaine de Caudoz - Viticulture RAC Changins (Switzerland)
RAC (CHE001)	Station Fédérale de Recherches en Production Végétale de Changins (Switzerland)
RAPD	Random Amplification of Polymorphic DNA
RBG	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Gardens, Kew, Wakehurst Place (United Kingdom)
RCA	Institute for Agrobotany (Hungary)
RDAGB-GRD	Genetic Resources Division, National Institute of Agricultural Biotechnology, Rural Development Administration (Republic of Korea)

RECSEA-PGR	Regional Cooperation in South East Asia for Plant Genetic Resources
REDARFIT	Andean Network on Plant Genetic Resources
REDBIO	Network on Plant Biotechnology in Latin American and the Caribbean
REDSICTA	System for Central American Integration for Agricultural Technology
REGENSUR	Plant Genetic Resources Network for the Southern Cone
REHOVOT	Department of Field and Vegetable Crops, Hebrew University of Jerusalem (Israel)
REMERFI	Mesoamerican Network on Plant Genetic Resources
RFLP	Restriction fragment length polymorphisms
RGC	Regional Germplasm Center (Secretariat of the Pacific Community) (Fiji)
RIA	Research Institute of Agriculture (Kazakhstan)
RICP (CZE061)	Genebank Department, Vegetable Section Olomuc, Research Institute of Crop Production (Czech Republic)
RICP (CZE122)	Genebank Department, Division of Genetics and Plant Breeding, Research Institute of Crop Production (Czech Republic)
RICP	Research Institute of Crop Production (Czech Republic)
RIGA	FAO Rural Income Generation Project
RIPV	Research Institute of Potato and Vegetables (Kazakhstan)
RNA	Ribonucleic Acid
RNG	School of Plant Science, University of Reading (United Kingdom)
ROCARIZ	West and Central Africa Rice Research and Development Network
ROPTA	Plant Breeding Station Ropta (Netherlands)
RPPO	Regional Plant Protection Organization
RRI	Rubber Research Institute (Viet Nam)
RRII	Rubber Research Institute of India
RRS-AD	Banana National Programme (Uganda)
RSPAS	Research School of Pacific and Asian Studies (Australia)
S9	Plant Genetic Resources Conservation Unit, Southern Regional Plant Introduction Station, University of Georgia, United States Department of Agriculture, Agricultural Research Services (United States)
SAARI	Serere Agriculture and Animal Production Research Institute (Uganda)
SADC	Southern African Development Community
SADC-FANR	Southern African Development Community, Food, Agriculture and Natural Resources Directorate

SADC-PGRN	Southern African Development Community, Plant Genetic Resources Network
SADC-SSSN	Southern African Development Community, Seed Security Network
SamAI	Samarkand Agricultural Institute named F. Khodjaev (Uzbekistan)
SANBio	South African Network for Biosciences
SANPGR	South Asia Network on Plant Genetic Resources
SAREC	Swedish Agency for Research Cooperation
SASA	Science and Advice for Scottish Agriculture, Scottish Government (United Kingdom)
SAVE Foundation	Safeguard for Agricultural Varieties in Europe (Foundation)
SCAPP	Scientific Center of Agriculture and Plant Protection (Armenia)
SCRDC	Soil and Crops Research and Development Centre, Agriculture and Agri-Food Canada
SCRI	Scottish Crop Research Institute (United Kingdom)
SDC	Swiss Agency for Development and Cooperation
SDIS	Documentation and Information System, Southern African Development Community Plant Genetic Resources Centre
SEABGRC	South East Asian Banana Germplasm Resources Centre, Davao Experimental Station, Bureau of Plant Industry (Philippines)
SEEDNET	South East European Development Network on Plant Genetic Resources
SFL	Holt Agricultural Research Station (Norway)
SGRP	System-wide Genetic Resources Programme
SGSV	Svalbard Global Seed Vault
SHRWIAT	Plant Breeding Station (Poland)
SIAEX	Junta de Extremadura. Servicio de Investigación y Desarrollo Tecnológico, Finca la Orden (Spain)
SIBRAGEN	Sistema brasileiro de informação de recursos genéticos
SICTA	Sistema de Integracion Centroamericana de Tecnologia Agricola (Central America)
SINAC	Sistema Nacional de Areas de Conservación (Costa Rica)
SINGER	System-wide Information Network for Genetic Resources
SKF	Research Institute of Pomology and Floriculture (Poland)
SKUAST	Sher-E-Kashmir University of Agricultural Sciences and Technology of Kashmir (India)

SKV	Plant Genetic Resources Laboratory, Research Institute of Vegetable Crops (Poland)
SMTA	Standard Material Transfer Agreement
SOUTA	School of Biological Sciences, University of Southampton (United Kingdom)
SoW	State of the World
SOY	Soybean Germplasm Collection, United States Department of Agriculture, Agricultural Research Services (United States)
SPB-UWA	School of Plant Biology, Faculty of Natural and Agricultural Sciences, University of Western Australia
SPC	Secretariat of the Pacific Community
SPCGF	Scientific Production Center of Grain Farming "A. I. Baraev" (Kazakhstan)
SPGRC	Southern African Development Community Plant Genetic Resources Centre
SPS	Sanitary and Phytosanitary Measures Agreement
SR, MARDI	Strategic Resource Research Centre MARDI (Malaysia)
SRA-LGAREC	La Granja Agricultural Research and Extension Center (Philippines)
SRGB SADC	Plant Genetic Resources Centre, Southern African Development Community (Zambia)
SRI	Sugar Crop Research Institute, Mardan (Pakistan)
SSA	Sub-Saharan Africa
SSC IUCN	Species Survival Commission, International Union for the Conservation of Nature
SSEEA	South, South East and East Asia
SSJC	Soutnern Seed Joint-Stock Company (Viet Nam)
SUMPERK	AGRITEC, Research, Breeding and Services Ltd. (Czech Republic)
SVKBRAT	Research Institute for Viticulture and Enology (Slovakia)
SVKLOMNICA	Potato Research and Breeding Institute (Slovakia)
SVKPIEST	Research Institute of Plant Production Piestany (Slovakia)
TAMAWC	Australian Winter Cereals Collection, Agricultural Research Centre
TARI	Taiwan Agricultural Research Institute
TaroGen	Taro Genetic Resources Network
TOB	Oxford Tobacco Research Station, Crops Science Department, North Carolina State University
TRI	Tea Research Institute (Sri Lanka)
TRIPS	Trade-Related Aspects of Intellectual Property Rights

TROPIC	Institute of Tropical and Subtropical Agriculture, Czech University of Agriculture
TROPIGEN	Amazonian Network for Plant Genetic Resources
TSS-PDAF	Taiwan Seed Service, Provincial Department of Agriculture and Forestry
TWAS	Third World Academy of Science
U.NACIONAL	Facultad de Agronomía, Universidad Nacional de Colombia
UAC	Université d'Abomey Calavi (Benin)
UACH	Banco Nacional de Germoplasma Vegetal, Departamento de Fitotecnia, Universidad Autónoma de Chapingo (Mexico)
UBA-FA	Facultad de Agronomía, Universidad de Buenos Aires (Argentina)
UC-ICN	Instituto de Ciencias Naturales (Ecuador)
UCR-BIO	Banco de Germoplasma de Pejibaye UCR-MAG, Escuela de Biología, Escuela de Zootecnia, Universidad de Costa Rica
UDAC	Unidade de Direcção Agraria de Cajú (Mozambique)
UDS	Ustymivka Experimental Station of Plant Production (Ukraine)
UH	University of Hawaii at Manoa (United States)
UHFI-DFD	Department of Floriculture and Dendrology, University of Horticulture and Food Industry (Hungary)
UHFI-RIVE	Institute for Viticulture and Enology, University of Horticulture and Food Industry (Hungary)
UM	Universiti Malaya (Malaya University, Malaysia)
UN	United Nations
UNALM	Universidad Nacional Agraria La Molina (Peru)
UNCED	United Nations Conference on Environment and Development
UNCI	Université Nationale de Côte d'Ivoire
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNMIHT	Horticulture Department, Michigan State University (United States)
UNSAAC	Universidad Nacional San Antonio Abad del Cusco, Centro K'Ayra (Peru)
UNSAAC/CICA	Universidad Nacional San Antonio Abad del Cusco
UPASI-TRI	United Planters' Association of South India-Tea Research Institute (India)
UPLB	University of the Philippines Los Baños
UPM	University Putra Malaysia

UPOU	University of Philippines Open University
UPOV	International Union for the Protection of New Varieties of Plants
URG	Unité des Ressources Génétiques (Mali)
USDA	United States Department of Agriculture
USP	University of South Pacific
UzRICBSP	Uzbek Research Institute of Cotton Breeding and Seed Production
UzRIHVWM	Uzbek Research Institute of Horticulture, Vine Growing and Wine Making named R.R. Shreder
UzRIPI	Uzbek Research Institute of Plant Industry
VEGTBUD	Station of Budapest, Vegetable Crops Research Institute (Hungary)
VINATRI	Tea Research Institute of Viet Nam
VIR	N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry (Russia)
W6	Western Regional Plant Introduction Station, United States Department of Agriculture, Agricultural Research Services, Washington State University (United States)
WABNET	West Africa Biosciences Network
WACCI	West African Centre for Crop Improvement
WADA (AUS137)	Australian Trifolium Genetic Resource Centre, Western Australian Department of Agriculture (Australia)
WADA (AUS002)	Western Australian Department of Agriculture (Australia)
WANA	West Asia and North Africa
WANANET	West Asia and North Africa Genetic Resources Network
WARDA	West African Rice Development Association
WASNET	West Africa Seed Network
WCF	World Cocoa Foundation
WCMC	World Conservation Monitoring Centre
WDPA	World Database on Protected Areas
WECARD/CORAF	West and Central African Council for Agricultural Research and Development
WICSBS	West Indies Central Sugarcane Breeding Station
WIEWS	World Information and Early Warning System on PGRFA
WIPO	World Intellectual Property Organization
WLMP	Sir Alkan Tololo Research Centre, Bubia (Papua New Guinea)
WRS	Cereal Research Centre, Agriculture and Agri-Food Canada
WSSD	World Summit on Sustainable Development
WTO	World Trade Organisation