Plant Genetic Resources Collections: A survey of issues concerning their value, accessibility and status as public goods

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Abstract
Plant genetic resources are one of the most important tools in agricultural research and development for the improvement of the productivity and sustainability of production systems, both in the developed and the developing world. There used to be plenty of diversity among crop varieties and their wild relatives, but this is rapidly disappearing, due to a trend towards uniformity in production systems and the disappearance of uncultivated areas which contain wild relatives. Fortunately there are now about 1500 genebanks or genebank collections in the world, in which a significant amount of the diversity is being conserved for future use. At the same time there is a growing awareness of the diversity that is still being grown in farmers fields, in particular in developing countries, and that concerted efforts have to be undertaken to conserve these genetic resources. However, while this diversity used to be available as a global public good, developments regarding intellectual property, plant variety rights and international agreements have made access and benefit sharing much more complicated and, thus, these developments affect the status of these genetic resources as public goods. In this paper we describe a range of developments that affect the value and the accessibility of plant genetic resources.

Media Summary
Agricultural biodiversity is essential for sustainable agriculture, now and in the future. Present developments are threatening its conservation for future use and its availability. Concerted action is needed.

Keywords
Genebanks, public goods, biodiversity, genetic resources, access, benefit sharing, wild relatives, genetic erosion

Introduction

It has been predicted that crop output worldwide must rise two-fold in the next couple of decades just to keep up with human population growth (Imperial College Wye 2003). This increase must occur – and be sustained – in the face of changing climates, diminishing land, stagnating yields, degradation of other natural resources and global conflict. To meet the need for more and high quality food, farmers will require crop varieties capable of producing under diverse and changing conditions, without increasing amounts of fertilizers and pesticides.

The basis for food security for present and future generations lies in the diversity of food crops. While only 15 major food crops provide more than 90% of the calorie intake of humans worldwide, human nutritional needs require a much wider diversity. This diversity is under threat as crop varieties adapted to specific environments, and with them the genes they carry, are subject to erosion and extinction.

As the amount of land available for conversion to agriculture diminishes, any increase in production must come from increasing yields rather than expansion of agricultural land. These yield increases will depend on the production of new varieties derived from a diverse genepool of cultivars and wild relatives. The world's crop genebanks hold much of the raw material needed to develop these varieties whilst providing increased yield, improved quality and greater nutritional value. The need to protect these *ex situ* collections of genetic diversity, as well as *in situ* and on-farm-maintained plant diversity, is an important challenge.

Common heritage and global challenges

The world has some 1500 genebanks and germplasm collections. The plant genetic resources held in them are an important part of humanity's agricultural heritage, resulting from 10,000 years of intentional and unintentional breeding for human use. Today's major food crops originated in areas that are only a fraction of the area where these crops are used today, including other continents. Thus farmers in any one region are dependent on “foreign” sources of genes to maintain the health of their crops, underlining the interdependence of countries in meeting food security and protecting what is traditionally viewed as global public goods.

This common agricultural heritage is in danger – it has been estimated that as many as 8% of plant species could disappear in the next 25 years. This is a direct threat to many wild relatives of crop plants. Over the past 50 years, genetically uniform crop varieties have replaced many thousands of landraces over huge production areas. Wild relatives are essential repositories of genetic traits needed for improving crop varieties now in use. Monocultures have resulted in genetically uniform crops that usually give high and uniform yields, but are considered very vulnerable to emerging pests and diseases (Marshall, 1977). Crop diversity provides an insurance policy against this danger, with genebanks serving as custodians for a reservoir of potentially useful genes and alleles for resistance to diseases and pests and other environmental stresses as well as for traits that increase yield. FAO estimates that three fourths of the original varieties of agricultural crops have been lost from farmers’ fields since 1900 (FAO 1998) and an IUCN study found that an estimated 30,000 plant species disappear each year (Gardiner and Le Goulven 2001), noting that the situation is further exacerbated by environmental stresses linked to global climate change. Thomas et al. (2004) estimated total plant species extinctions in Amazonia following maximum expected climate change leading to habitat destruction or climatic unsuitability at 69% for species with seed dispersal and at 87% without seed dispersal. This shows that the danger posed to wild relatives of crop plants is critical. The clearing of forests and the spread of urban areas is also resulting in the disappearance of wild relatives of crop plants

The crucial role of collections

Combating hunger and poverty will require unhindered, although not necessarily free, access to crop diversity that farmers and breeders need to keep ahead of pests, diseases and climatic shocks that continually threaten agriculture. Genetic diversity provides farmers and plant breeders with options to develop, through selection and breeding, new, resilient and more productive crops. Collections of crop diversity held in *ex situ* genebanks appeared only in the 20th century. There are now approximately 1470 collections in national, regional and international institutes around the world holding, collectively, about 5.4 million samples of crop resources. These collections, at the moment mainly through inadvertent as well as safety duplications, are growing in size as well as increasing in number and are located in more than 100 countries around the world. Approximately 11% (equal to approximately 40% of unique accessions) are held in the 11 genebanks of the Future Harvest Centres of the Consultative Group on International Agricultural Research (CGIAR) and more than a third are stored in 15 national genebanks. The global responsibilities shouldered by these facilities, and the need for resources to carry them out, are enormous. Not only do they collect and conserve the accessions – they must also document, regenerate, evaluate and distribute them to users. In doing so, they must ensure the genetic integrity and health of the samples.

Information generated throughout this sequence of activities must be stored in easily accessible fashion. . Dissatisfaction with the quantity, quality and availability of information on the accession level is the most frequent concern expressed by genebank clients (Fowler and Hodgkin 2004). Another is loss of viability of germplasm resulting from poor storage conditions and regeneration backlogs in genebanks. The information situation has improved in the last few years. The CGIAR System-wide Information Network for Genetic Resources (SINGER) provides access to data on the plant collections held in trust by the Future Harvest Centres, the US Genetic Resources Information Network (GRIN) DA system and the European EURISCO system provide access to data on collections held in the US and European collections. However, much remains to be done.

International agreements

In the following paragraphs, we provide a brief overview of some of the most important international agreements that have come into existence in the last thirty years that affect the way different classes of plant genetic resources for food and agriculture (PGRFA) are exchanged, conserved and used. Such surveys are very common in legal and policy related literature in the field. Our purpose here is only to highlight the fact that the international legal framework has generally increased the number of layers of potential obligations and restrictions for the exchange and use of PGRFA. This complicates and in some cases undermines conservation and research activities. Not all developments in international law contribute to this trend. For example, the International Treaty on Plant Genetic Resources for Food and Agriculture, which will come into force in 2004, should facilitate easier, regular and cheaper exchanges of a core group of crops and forages.

Up to the middle of the last century, it was taken for granted that genetic resources should be freely shared as the common heritage of humanity. However, in the 1960s, plant breeders' rights began to be enunciated, with royalties paid to scientists and companies that developed new varieties. In 1963, the first International Convention on the Protection of Plant Varieties (UPOV 1961) was created to harmonize the intellectual property laws of a number of developed countries to protect plant varieties. In 1972 and 1978, the Convention was revised and expanded in scope to cover all plant varieties that satisfied the criteria of being distinct, uniform and stable. Despite these developments, the International Undertaking on Plant Genetic Resources, 1983, a non-binding set of guidelines created under the auspices of the FAO, held that all PGRFA was the common heritage of human kind. Those member countries of the UPOV convention with plant breeders' rights laws contested this undertaking. Ultimately, those UPOV countries' positions came to be reflected in a resolution, adopted in 1989, that as an exception to the concept of common heritage, plant breeders rights would be recognized. As a counterpoint to this development, the concept of farmers' rights began to garner support in the late 1980s. Developing countries felt that their genetic resources were being exploited by developed countries, without compensation, in the creation of new varieties that developed countries were protecting with plant breeders rights. Farmers Rights were recognized in a second 1989 resolution. It is possible to reconcile the two concepts as UPOV 1978 allowed relatively broad exemptions for farmers to exchange and save protected seed, thereby simultaneously recognizing a private right of companies to protect their commercial market in seed, but respected the age-old practices of farmers in informally saving and distributing seeds. The tensions between plant breeders rights and farmers rights were a potential point of controversy and became more so with the 1991 revision of the UPOV Convention (see below).

At the same time concerns about loss of biodiversity were growing, based on the rapid uptake of Green Revolution varieties leading to the disappearance in many areas of traditional crop varieties. It became evident that farmers alone cannot and should not be responsible for ensuring the continued safe conservation of the crop diversity that is necessary for food security far beyond their local communities. A consensus grew that the world community must take responsibility for conserving and managing global public goods like genetic resources. The major international agreements to ensure this have only appeared in the last thirty years:

UPOV 1991

In the 1991 UPOV Convention the farmers exemption, which was 'built into' the 1978 Convention, became an 'option' for countries to put in place. The option was narrowed in scope. Under the 1991 convention countries can allow exemptions for farmers to save and plant back seeds for their own use. Most commentators argue that exchange of seed or seed sales by farmers is no longer permissible. If a country chooses not to implement these exemptions, then the 1978 farmers' exemption as embodied in UPOV 1978 disappears entirely. Both UPOV 1978 and 1991 include exemptions for the use of protected material (on a limited number of occasions) for the purposes of research. Countries wishing to join UPOV, and take advantage of the benefits of belonging to the community of countries that have harmonized plant variety protection laws, now must subscribe to the standards of UPOV 1991; it is no longer possible to join and opt to implement UPOV 1978.

Convention on Biological Diversity, 1992

The CBD was finalized at the Rio Earth Summit in 1992 and has been ratified by over 175 countries. It seeks to ensure the conservation of biological diversity, the sustainable use of its components, and an equitable sharing of benefits. Article 15 of the CBD affirms the sovereign right of all countries over their natural resources and their authority to regulate access to genetic resources. It also states that when countries do agree to provide access, it shall be subject to prior informed consent and under mutually agreed terms. This framework, while useful, leaves a great deal of flexibility to countries about how they regulate/facilitate access to genetic resources within their borders. In the initial rush of enthusiasm about the monetary (and other) benefits that countries would realize through rigorous enforcement of controls over access to their biodiversity, many countries started to develop national legal frameworks to set the stage for case-by-case, ad hoc, bi-lateral negotiations between applicants and the government of the country within which the resources were located (with the option of including private individuals or communities that had a claim to an interest in the resources in question). The Andean Pact Decision 391, 1996, (the first regional access agreement after the CBD came into force), and the Philippine Law Executive Order 247, 1995, (the first national access law after the CBD came into force) are good examples of this approach to regulating access. More recently, the 6th Conference of the Parties to the CBD (COP 6) adopted non-binding guidelines, called the Bonn Guidelines, to help countries think-through some of their options when putting access regulations in place. Those guidelines aim to create regulations that set the framework for bilateral negotiations for access (i.e., case-by-case negotiations between those seeking access and government bodies with the power to grant access with provisions to seek the consent of local communities where appropriate). Now, twelve years after the CBD came into force, there are still very few examples of regulations leading to significant benefit sharing agreements. Many countries are currently developing bilaterally oriented access laws, and it is possible that profitable agreements may be struck in the future. However it is fair to say that there is now much less optimism about the potential for these laws to leverage significant funds to contribute to genetic resources conservation than there was in the late 1980s and the 1990s.

TRIPS

The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which is an annex to the agreement establishing the World Trade Organization (WTO), establishes minimum standards of patents and plant variety protection for all WTO member states. Article 27 requires all member states to provide patent protection for all products and processes including pharmaceuticals, microbiological processes and modified microorganisms. They may exclude plants and animals from patentability. However, article 27(3)(b) states that states must provide patent protection and/or 'effective *sui generis* protection' for plant varieties. Significantly, TRIPS does not mention the UPOV Conventions, and leaves it open to countries to put in place forms of intellectual property protection that are less stringent than UPOV 1991 or UPOV 1978.

The International Treaty on Plant Genetic Resources for Food and Agriculture (IT), coming into force in 2004

While bilateral approaches may still be appropriate for many kinds of genetic resources – e.g. wild and endemic species, they are not necessarily the most appropriate for PGRFA, for many reasons. These include the fact that many crops are already widespread around the world, their importance to food security, and in national and international breeding and conservation programs. All these depend on relatively high volume, low cost exchanges of PGRFA to move forward. For these reasons, bilaterally-oriented access mechanisms may potentially impede the patterns of access and exchange of PGRFA that are necessary for conservation and development. The International Treaty, which is fully in harmony with the CBD, represents an alternative to bilaterally oriented regulations for PGRFA. Instead, countries that ratify the IT have chosen to exercise their sovereignty and authority to regulate access to their genetic resources by setting up a multilateral system of access and benefit sharing (MLS) for a set list of 35 species of crops and a number of forages. Pursuant to this system, member states can gain access to the collections of listed crop and forages held by other member states (that is not subject to intellectual property rights) in exchange for allowing those other states access to their own collections of listed materials. The Treaty pre-establishes the conditions for exchanges of materials. No new negotiations are necessary (or allowed) with respect to listed materials. Those conditions include the following: material accessed through the MLS must be used for agricultural research and/or conservation purposes. It may not be used for pharmaceutical research, for example. Recipients are not allowed to claim intellectual property rights on material they receive. They are allowed, however, to seek intellectual property rights on new PGRFA products they develop using material they receive from the MLS. In such cases, however, if they commercialize that product, and the form of IPR they use actually prohibits third parties form using the material for research purposes, then they must pay a percentage of the money they make from commercialization into an international fund that is established pursuant to the Treaty. The fund will be used to support conservation efforts around the world. Pursuant to this system, parties who are members of the MLS should be able to secure access to listed material from other participating states for the purposes of research and conservation relatively quickly and for little money.

The International Agricultural Research Centres of the CGIAR are invited, in Article 15 of the IT, to sign agreements with the governing body of the IT to place their collections under the auspices of the IT. The relevant Centres have already indicated that they are willing to do so. Their materials will, therefore, be included with the MLS on exactly the same conditions as materials held by participating state parties. The IT will come into force 90 days after it has been ratified by 40 countries. At the end of February 2004, 35 countries have ratified. It is expected to come into force in mid to late 2004. To enter into agreements with the governing body, the IARCs must wait until after the Treaty comes into force.

WIPO's IGC

The Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC), convened under the auspices of the World Intellectual Property Organization (WIPO) has held five meetings since April 2001. The IGC did not have a mandate, over the course of those five meetings, to develop binding international commitments. Instead, it focused on in depth investigations of technical issues that arise at the intersection of intellectual property rights, traditional knowledge and genetic resources, and developed interesting tools associated with those issues. For examples, the IGC has compiled a) a data base of intellectual property related legal clauses associated with contractual exchanges of genetic resources, b) a compilation of national laws and legal instruments that provide forms of protection for traditional knowledge, and c) a pilot data base to be included in national patent offices 'prior art' searches. By way of an agreement between IPGRI, on behalf of the System-wide Genetic Resources Programme (SGRP) and WIPO, the System-wide Information Network for Genetic Resources (SINGER) was linked to the WIPO pilot site for prior art searches in 2003. In 2003, the WIPO General Assembly provided the ICG with a new mandate, leaving open the possibility that it could decide to develop an internationally binding instrument concerning, among other things, genetic resources and traditional knowledge. The first meeting of the IGC with this mandate is expected to take place March 15-19, 2004. Based on past experience of the IGC, it is likely that most developing countries will favour a binding international instrument, and developed countries will not. In the past, delegates have generally not linked their consideration of genetic resources issues at the IGC to the existence of the International Treaty. It will be critically important, as far as PGRFA is concerned, that delegates do consider the existence of the Treaty (see section on the IT above), and bear in mind all of the special aspects of PGRFA that justified its being subject to the kind of treatment it receives in the Treaty.

Examples of two (IPGRI-related) projects created to analyze options at national and regional levels: ABS and GRPI project

The forgoing developments in international law are relatively complex, and it is not entirely clear in all cases how these agreements relate one to another. It is a daunting task for most countries to decide whether or not to sign onto some of these agreements, and if they do, it is still more complicated to determine how they should be implemented into national laws. The scenario is complicated further by the fact that, not surprisingly, these international agreements do not address all of the priority issues that exist with respect to the conservation and use of genetic resources on the ground in many countries. National priorities that are not reflected in these agreements therefore have to be 'squared' with these international obligations (when and if countries decide to take them on). In light of these facts, a number of projects, coordinated at international levels have been developed to try to lend assistance to national policy makers in working through these complexities. In the following two paragraphs, we provide details about two such projects coordinated by IPGRI to provide a flavour of the some of the work that is ongoing.

The Access and Benefit Sharing (ABS) Project

Through a series of regional meetings and commissioned background studies, the ABS project will develop a tool to assist national and sub-regional policy makers to decide what kind of access and benefit sharing scheme they should adhere to and implement into national laws. The toolkit will take national and regional decision makers through a checklist of questions to help them determine what their PGRFA-related strengths and weaknesses are, and what their reasonable expectations can be in terms of developing PGRFA-related sectors in their respective countries. The tool kit will assist decision makers to link this data to different policy and legal options.

The Genetic Resources Policy Initiative (GRPI)

In its first phase, GRPI supports national multi-stakeholder, multi-disciplinary multi-sectorial teams to identify and prioritize policy and legal issues concerning the conservation, use and exchange of genetic resources for food and agriculture (GRFA). In its second phase, GRPI supports those teams to undertake research and capacity strengthening activities to address priorities identified. The project's focus on a multi-sectorial, multi-disciplinary and multi-stakeholder *modus operandi* responds to the reality that the conservation and use of GRFA, and the policies and laws that are necessary to support them, cut across sectorial boundaries, requiring expertise from numerous disciplines and engaging the interests of a wide range of stakeholders. GRPI is based on the appreciation that the processes that are followed in national contexts are as important as, and inextricably linked to, the results of those processes. As a result, considerable time has been spent in the first phase of the project to establish national working groups and to strengthen their capacity to actually conduct the priority setting exercises and to develop work plans that respond to those priorities. GRPI is supporting these activities in Vietnam, Nepal, Egypt, Zambia and Ethiopia.

Global Public Goods

It is against the background of the international agreements above that IPGRI policy studies investigate how a balanced system that recognizes the legitimate rights of all parties can be developed. A successful system must ensure the maximum conservation, use and exchange of GRFA in support of food security, poverty alleviation and environmental sustainability. Central to these rights is the concept of genetic resources as global public goods that require unimpeded and fair availability, access and equitable sharing of benefits.

The traditional definition of global public goods is based on their inclusiveness (no users/beneficiaries are excluded) and the fact that they exist outside national or other boundaries. Equitable access to public goods and a fair sharing of the benefits accruing from international public goods are desired and, to ensure this, it is important that a full range of stakeholders (in the case of genetic resources this would include plant breeders, researchers, farmers, decision makers in national governments, community groups, regional networks and the private sector) be involved in allocating both access and benefits.

As pointed out by Fowler and Hodgkin (2004), access and benefit sharing can be impeded, denied or facilitated by policy and law, although the large *ex situ* collections reflect the fact that facilitation has usually prevailed. They outline a process through which use of genetic resources takes place, from maintenance of diversity of genotypes (landraces, varieties), genes and alleles and characterization and evaluation to the provision of information on trait expression, control and the introduction of new variability. Effective use of genetic resources involves each stage in the process; any limitations in one stage can affect all the others.

Information: a subsidiary public good

Perhaps the most important part of the genetic resources use process is the provision of information obtained through collecting, characterization and evaluation – it may be argued that this information is as much a public good as the genetic resource itself, in particular when one realizes that the biological material without the information on how to utilize it can hardly be regarded as a genetic *resource*. It is the experience and knowledge of farmers collected and developed over centuries by growing and improving and adjusting the crop that has resulted in the genetic resource as we know it today. Therefore, the raw material in germplasm collections cannot be used effectively without information on agronomic practices and the genetic traits of value to users including the harvested produce for food preparation and/or other uses. This information is obtained from farmers during the collecting of the germplasm material as well as through characterization and evaluation of the genetic material, often using molecular methods. The free exchange of information, like the flow of germplasm, can be impeded or facilitated by policies and legal instruments, so that provision of information on genebank holdings by information networks such as SINGER, are crucial to management and use of the collections.

One component of information on genetic resources is the traditional knowledge that has accumulated in communities through experience; farmers' rights, seeking to protect this knowledge, have become a contentious issue. The challenge facing international negotiators of intellectual property rights is to simultaneously improve farmers' livelihoods and contribute to the optimum use, conservation and exchange of PGRFA as public goods. IPGRI attempts to ease tensions between developing and developed country negotiators by making the case that both Northern and Southern countries would benefit from the adoption of a multilateral system of exchange. Studies carried out by IPGRI demonstrate that current flows of germplasm are advantageous to developing as well as developed countries. Case studies for 15 developing countries produced data showing that the number of germplasm samples received from the CGIAR collections were many times more than these countries contributed to the collections over the period 1972-1991. (Fowler, Smale and Gaiji, 2003) Subsequent analysis of records of key crop accessions from six of the CGIAR Centres (CIAT, CIMMYT, ICARDA, ICRISAT, ILRI and IRRI) showed that more than 80 percent of the materials distributed by genebanks went to organizations in developing countries, the vast majority being universities and national agricultural research systems (SINGER, 2003).

Overview of the In-Trust Collections

In 1994 the collections of the 11 CGIAR genebanks were placed under the auspices of FAO for the benefit of the world community. Under this agreement, the CGIAR Centres, as well as all recipients of material from their in-trust collections, do not exercise ownership or hold intellectual property rights over the material and related information. The CGIAR Centers hold about 600,000 accessions, the bulk of which is held in trust (Table 1). These collections represent 40% of the world's unique germplasm diversity for major food crops that is maintained in genebanks worldwide. Their combined collections together with the characterization and evaluation data represent a global public good of great utility to breeders and researchers, with virtually every country in the world being a net beneficiary. It has been estimated (Imperial College Wye, 2003) that the CGIAR genebanks distributed more than a million plant samples to users worldwide in the last 20 years, with the bulk going to developing countries.

These collections are a cornerstone of the international system of germplasm conservation and management. Using germplasm conserved by the CGIAR, crop breeders inside and outside the CGIAR developed improved crop varieties that were taken up by farmers the world over. The result has been very significant increases in crop yields in the past several decades with benefits of many billions of dollars for developing country producers (through increased productivity and lower costs of production) and consumers (through lower food prices and improved quality) (Alston et al. 2000).

Table 1: CGIAR genebank in-trust holdings Germplasm holdings of the CGIAR Centres (available in the System-wide Information Network on Genetic Resources, SINGER) by crop/species and the number of each category designated in trust under the auspices of FAO in October 1994 (FAO, 2002).

Centre	Crop	Number of Accessions
CIAT	Cassava	5,728
	Forages	18,138
	Bean	31,718
CIMMYT	Maize	20,411
	Wheat	95,113
CIP	Andean roots and tubers	1,112
	Sweet potato	6,413
	Potato	5,057
ICARDA	Barley	24,218
	Chickpea	9,116
	Faba bean	9,074
	Wheat	30,270
	Forages	24,581
	Lentil	7,827
ICRAF	*Sesbania*	25
ICRISAT	Chickpea	16,961
	Groundnut	14,357
	Pearl millet	21,250
	Pigeon pea	12,698
	Sorghum	35,780
	Minor millets	9,050
IITA	Bambara groundnut	2,029
	Cassava	2,158
	Cowpea	15,001
	Soybean	1,909
	Wild *Vigna*	1,634
	Yam	2,878
ILRI	Forages	11,537
IPGRI	*Musa*	931
IRRI	Rice	80,617
WARDA	Rice	14,917
Total		532,508

Genes in the genebank collections

Genebank collections can be considered as repositories of a particular type of global public good -- genes and their alleles that are of actual or potential utility to breeders and researchers, a utility that is often apparent only in response to unforeseen challenges. The value of these genes and alleles lies in their potential to ensure the stability of the world’s food supply as well as the adaptability of the crops on which that supply rests. Both production stability and crop adaptability are dependent on the genetic diversity contained in genebank collections. Only a small number of traits have already been identified but many are still to be discovered and described. Most of these traits that have already been identified are known only on a phenotypic level; on a genotypic level the available information on useful traits is even less abundant. However, as the need for readily available genetic and genomic information to use in targeted applications has grown, so has interest in and support for molecular evaluation of genebank material. Recent developments in biotechnological applications, particularly with regard to molecular markers, allow a much more precise identification and definition of genes, alleles and the useful traits they underlie. As more of this information becomes available, a greater and more targeted use of collections can be predicted. This will result in more information about traits such as disease and pest resistance, suitability for specific growing conditions and climatic zones, nutritional requisites and addressing balances in agro-ecological systems.

These developments in the use of genebank collections, as was pointed out by Frankel in 1989 (Koo, Pardey & Wright, 2002), are likely to lead to a focus on activities such as the provision of basic information and the construction of a network to enable better information flow, rather than allocating scarce financial resources primarily to the expensive evaluation of rarely used alleles. With genetic marker techniques and genomic information, evaluation of useful traits and the development improved cultivars incorporating these traits is becoming become both cheaper and faster (Koo & Wright, 2003)

Strengthening plant genetic resources as global public goods
Developments in recent years have heightened the public nature of the debate over fair access and benefit sharing and have strengthened the role of global institutes and instruments in protecting these public goods as well as ensuring access to them and the information associated with them. The Global Crop Diversity Trust and the Challenge Programme on Unlocking Genetic Diversity are two of these developments:

Global Crop Diversity Trust
The Global Crop Diversity Trust is being established as an international fund whose goal is to support the conservation of crop diversity over the long term. The establishment of the Trust involves a partnership of FAO and the CGIAR. The Trust aims to match the long term nature of conservation needs with long term secure and sustainable funding by creating an endowment that will provide a permanent source of funding for crop diversity collections around the world. The endowment will ensure the perpetual conservation of eligible collections meeting agreed standards of management. The Trust will also provide technical and capacity building assistance to eligible collections seeking to meet such standards. Finally, the Trust will promote and assist the development of a rational and efficient system of crop diversity conservation in genebanks around the world.
The Trust seeks to support the obligation of institutions and governments to:

- the commitment to FAO to hold the genetic resources collections housed in the CGIAR Centres in trust for humanity
- the pledge of the FAO Global Plan of Action for Plant Genetic Resources to create and support a rational system of crop diversity collections around the world
- the International Treaty's objective to promote the development of an efficient and equitable global system of genetic resources exchange

The partners in the campaign for the Trust are currently consulting with a wide range of interested parties to ensure that the views of all relevant stakeholder groups are taken into account in setting up the endowment.

Unlocking Genetic Diversity in Crops for the Resource Poor – a Challenge Programme
The CGIAR has recently taken the initiative for a large research programme that aims to use molecular tools to unlock the genetic diversity in Genebank collections, for transfer to breeding programmes. This Challenge Programme brings together advanced research institutes, national programmes from developing countries and many of the CGIAR institutes. CIMMYT, IRRI and IPGRI were the founders of this Challenge Programme.

Apart from advancing state-of-the-art techniques for molecular characterization of germplasm, a main thrust of the programme is on developing molecular toolkits and information systems for other crops than the 'big five' model plant species (rice, *Arabidopsis*, medicago, wheat and maize), including crops such beans, cassava, banana and millets. The main focus in the challenge programme will be on the genetic understanding and identification of drought tolerance in accessions. Special emphasis is placed on training and capacity building. Within the challenge programme, policy and legal research is being carried out to develop a system that will allow fair access of all countries to the results of the programme and will hopefully be the benchmark for similar research efforts elsewhere.

Conclusion: Meeting the challenge

Global public goods: To summarize, ways must be found to ensure an increase in agricultural productivity in order to keep pace with the rise of the world population and the growing demand for good quality food. This increase must occur, and be sustained, in the face of climate change, diminishing land availability and global conflict. The challenges are global in nature; the strategies to be developed and the tools made available to meet these challenges must also be global in nature. Agricultural biodiversity, and specifically crop genetic resources, are the result of millennia of agricultural activity by farmers from every region of the world and qualify as global public goods that require global efforts to ensure that all countries have fair access and equitable share in benefits. Farmers will require crop varieties capable of producing under diverse conditions. With little land left to bring under cultivation and a projected 3 billion increase in world population by 2050 (almost all occurring in poorer countries), yields must continue growing.

Genebanks are the most important sources of potentially useful genetic diversity for improving quantity and quality of agricultural yields and for adapting crops to changes in climate and in meeting environmental stresses. The latter might include crop varieties suitable for shorter growing seasons, increased drought or flood conditions, higher temperatures, increased soil salinity and changing patterns of pest infestations and diseases

Global genebank system: To achieve food security we need to rely on the diversity (and the genes and their alleles on which that diversity is based) that is housed in germplasm collections as well as the diversity that can still be found in farmers' fields in centers of diversity. This can only be done if there will be fair (although not necessarily free) access to collections for all bona fide users, while the benefits derived from its use will also be fairly shared. This requires a global system for managing genebanks as well as the resources to make it happen. Unfortunately the Future Harvest Centres as well as other Genebank holding institutions find it increasingly difficult to secure the level of funding needed each year to ensure that the long-term conservation operations are adequate.

Consultations with multi-stakeholders: Genebanks, as custodians of global public goods, must become more proactive participants in the planning of agricultural production systems in terms of what kinds of crops and varieties to use. Strategies need to be developed for ensuring wide consultations of stakeholders in decision-making regarding conservation and use priorities and in the provision of access and the sharing of benefits. To do this, it is important for genebanks to establish close links with user communities.

Information and public awareness: Genebanks should be centres of information on genetic resources and be able to provide relevant information to every potential user, as well as policy makers and the general public. Global support is needed for information networks such as SINGER that facilitate informed use of genebank collections. An important question will be whether the increased use of molecular tools in genebanks will make genebanks into true "banks of genes", and whether for example sequence data will be freely available or need to be protected. It is likely that information systems will become more important. Furthermore it is important for genebanks and associated global institutions to carry out public awareness campaigns targeted to both policy makers and the general public.

Policy and legal instruments: As outlined above, many legal instruments and policies have been developed in the last two decades to address questions of equity in benefit-sharing and access to global public goods. With the coming into force of the International Treaty on Plant Genetic Resources for Food and Agriculture, it is possible that formal constraints may significantly reduce for those crops covered by the Treaty's multilateral system. (Fowler and Hodgkin, 2004). At the time this paper is written, it seems likely that the Treaty will come into force in July of 2004. This will allow us to monitor the system embodied in the Treaty during the next couple of years, to see which constraints will disappear, which will remain, and which new ones will arise.

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