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International Law of Relevance to Plant Genetic Resources: A practical review for scientists and other professionals working with plant genetic resources

Susan Bragdon (editor)

Abstract

While controversies over the ownership, control and exchange of plant genetic resources for food and agriculture (PGRFA) are old, modern-day management of these resources is more complicated than ever before. Developments in international and national law and policy over the past 15 years have changed the working environment for those in charge of managing and making decisions about genetic resources. Today genetic resource managers need to understand the legal and policy environment in order to do their jobs effectively.

Those who participate in policy-making face an equally bewildering environment. Trade relations, intellectual property rights, biosafety, indigenous communities and public–private sector relations are just a few of the topics that are always on the table. In addition, everyone faces the prospect of dealing with numerous laws, regulations, guidelines and policies and following events in multiple fora, from those at the national level to the international level. Different political and scientific interests compete for what they want or think is right. And yet, at the end of the day it is clear that nations and people are interdependent for plant genetic resources. This simple fact dictates that we cooperate to ensure the conservation of PGRFA and its orderly management, including the facilitation of access and fair benefit sharing.

The task of understanding all the issues of relevance to the conservation and management of plant genetic resources is extremely complex. Derived from the substantive chapters of a comprehensive training manual, this Issues Paper attempts to guide the reader through the international agreements and policies of most relevance to the conservation and management of PGRFA, focusing on how they can be understood, implemented and shaped. In addition, there is a chapter discussing cross-cutting issues. This Issues Paper also contains annexes for the reader wishing to have a better understanding of the economic issues that are integral to the international policy and law-making environment.

SGRP

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Issues in Genetic Resources is an occasional series of papers published by IPGRI on important topics of interest to the genetic resources community.

The International Plant Genetic Resources Institute (IPGRI) is an independent international scientific organization that seeks to advance the conservation and use of plant genetic diversity for the well-being of present and future generations. It is one of 16 Future Harvest Centres supported by the Consultative Group on International Agricultural Research (CGIAR), an association of public and private members who support efforts to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment. IPGRI has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

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The System-wide Genetic Resources Programme (SGRP) joins the genetic resources programmes and activities of the Future Harvest Centres in a partnership whose goal is to maximize collaboration, particularly in five thematic areas. The thematic areas—policy, public awareness and representation, information, knowledge and technology, and capacity-building—relate to issues or fields of work that are critical to the success of genetic resources efforts. The SGRP contributes to the global effort to conserve agricultural, forestry and aquatic genetic resources and promotes their use in ways that are consistent with the Convention on Biological Diversity. IPGRI is the Convening Centre for SGRP. The Inter-Centre Working Group on Genetic Resources (ICWG-GR), which includes representatives from the Centres and the Food and Agriculture Organization of the United Nations, is the Steering Committee.

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Foreword

The policy and legal environment within which scientists and other professionals concerned with the conservation and development of plant genetic resources work has changed dramatically over the last couple of decades. Scientific advances, the increased privatization of agricultural research and other processes of "globalization" have created a legal and policy environment that reaches into and affects the conservation, use, development and management of plant genetic resources. Today, scientists and other professionals dealing with plant genetic resources cannot access, develop or conserve these resources without negotiating their way through a complex set of laws and policies.

The legal and policy issues affecting the conservation and management of plant genetic resources for food and agriculture (PGRFA) are numerous and multifaceted. Further complicating matters, the legal system (insofar as it can be called a "system") affecting the conservation and management of PGRFA has developed piecemeal over time and increasingly in various fora with distinct interests and motivations. As the introduction to this volume so aptly notes, a genetic resource professional making decisions without considering the policy and legal implications may result in an inadvertent misstep and a corresponding account on the front page of a well-read newspaper!

Some legal issues arise from obligations derived from international law and the interrelationship of different agreements. Some legal questions and systems that were initially primarily national in character through globalization have become "internationalized" (e.g. intellectual property rights under the TRIPS Agreement). This Issues Paper focuses on law and policy that emanates from the international arena, though as the introduction and chapter one note, the dynamic between these two levels affects developments nationally and internationally.

This Issues Paper is an attempt to give genetic resources professionals the information they need to be more sensitive to the policy and legal environment in which they do their work. Other more in-depth analysis of each of the treaties covered is available. This volume has a practical goal. Its aim is to increase the confidence of genetic resource professionals that they are operating and making maximum use of and not running afoul of policies or laws as they go about their important business of conserving, developing and managing plant genetic resources.

The chapters in this book were prepared as part of a larger process of the CGIAR System-wide Genetic Resources Programme (SGRP) to respond to the need of genetic resource professionals for training in laws and policies of relevance to genetic resources. A comprehensive training module with lectures, presentations, exercises and explanatory notes has been produced by IPGRI and ISNAR for SGRP and is available on CD-ROM.[1] Opportunity for translation from English to other languages; its adaptation for regional and sub-regional "training of trainers" workshops, and its wide dissemination and for keeping the material up-to-date is being sought.

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[1] Bragdon, S., Fowler, C. and Franca, Z. (eds). SGRP, IPGRI and ISNAR. 2003. Law and Policy of Relevance to the Management of Plant Genetic Resources. Learning Module. International Service for National Agricultural Research, The Hague, Netherlands.

I. Introduction

While controversies over the ownership, control and exchange of plant genetic resources for food and agriculture (PGRFA) are old, modern-day management of these resources is more complicated than ever before. Those in charge of the physical care of PGRFA could be forgiven for complaining that they need degrees in politics, law and genetics just to survive. And, those who participate in policy-making face an equally bewildering environment. Trade relations, intellectual property rights, biosafety, indigenous communities and public–private sector relations are just a few of the topics that are always on the table. In addition, everyone faces the prospect of dealing with numerous laws, regulations, guidelines and policies, and following events in multiple fora, from those at the national level to the international: FAO, the Convention on Biological Diversity, World Trade Organization, World Intellectual Property Organization, etc. The complexity and contentiousness of the new biopolitical environment is reflected in new language that did not exist 25 years ago: GMOs, biopiracy, Farmers' Rights, Frankenstein Foods, and more. The consequences of not being up to date and knowledgeable about all these matters and fora can be costly, both professionally and institutionally. One misstep and a genetic resource professional can end up reading about him/herself in the morning newspaper! To help serve as a reference throughout this book, Table 1.1 provides a summary of the relevant instruments, their scope of coverage and their current status.

Different political and scientific interests compete for what they want or think is right. And yet, at the end of the day it is clear that nations and people are interdependent for plant genetic resources. This simple fact dictates that we cooperate to ensure the conservation of PGRFA and its orderly management, including the facilitation of access and fair benefit-sharing.

These chapters are intended to provide a basic foundation in international laws and policies of relevance to genetic resources for those who have practical management and/or policy-making responsibilities for plant genetic resources. It is intended to help genetic resource professionals understand the policy environment in such a way as to promote the sound and scientific management of PGRFA whether in their role as custodians and developers of this resource or as policy-makers. This audience's interest in the subject is not "academic". It is practical. Thus, the chapters focus not so much on the political issues that underlie existing laws, agreements and policies, but on how these can be understood, implemented and shaped.

This Issues Paper includes an extensive section on the International Treaty on Plant Genetic Resources, as well as a section on the Convention on Biological Diversity. Both agreements have implications for how genebanks and breeding programmes manage collections/materials, as well as for the laws, policies and regulations that countries adopt to promote implementation. Genetic resource professionals will be interested in understanding these legal agreements because of a practical need to make sure that their governments or institutions are meeting legal requirements and taking actions appropriate for the implementation of the agreements. The average user will probably not need to know everything about the agreements. More complete academic analyses of the Treaty and the Convention are or will shortly be available. This Issues Paper focuses on the areas that have immediate practical implications for the work of genetic resource professionals. The hope is this Issues Paper will help these professionals become more knowledgeable, sensitive, confident and effective actors in the field of plant genetic resources.

This Issues Paper will first cover the history and development of law and policy of relevance to genetic resources. This puts current policies, laws and controversies in context and illustrates that the legal "system" is dynamic and evolutionary. Chapter 3 outlines

the FAO global system before turning to the International Treaty, the subject of Chapter 4. The analysis of international legal instruments continues in Chapters 5 – 9 which look at the convention on Biological Diversity, the WTO/TRIPS agreement, UPOV and phytosanitary and biosafety measures respectively. The Issues Paper concludes with a discussion of the cross-cutting issues that arise from these laws and policies. Because economic issues and instruments are important aspects of law and policy, this Issues paper contains two annexes addressing economic issues. Annex 1 explores the economic concepts for on-farm and *ex situ* conservation of crop genetic resources. Annex 2 looks at the changing roles of private and public agricultural research and effects on the utilization, access to, and conservation of PGR.

Table 1.1. Legal instruments for PGRFA, their coverage and status

Law or Policy	Topic / Applicability	Status / Jurisdiction
International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)	Covers all PGRFA (does not regulate non-food and agricultural uses) and addresses diverse topics, including conservation, use, international cooperation, technical assistance, and farmers' rights Establishes multilateral system for select crops (approx. 35 crops/crop complexes plus certain forages) Sets rules for access and benefit-sharing for these materials, both *ex situ* and *in situ*, while respecting property rights Does not specify access and benefit-sharing rules for non-multilateral system PGRFA (except for CGIAR holdings of such crops that are currently covered under FAO–CGIAR "in-trust" agreements).	Adopted by FAO Conference in 2001 Entry into force after the 40^{th} country ratifies Legally binding for all countries that ratify; will not apply to those that do not Countries that ratify will be required to bring national laws and regulations into conformity with the Treaty CGIAR Centres will likely sign agreements with the Treaty's Governing Body in order to adhere to the Treaty formally *Note: some of the Treaty's provisions (e.g. Farmers' Rights) are phrased in ways that do not create specific, prescribed (enforceable) obligations or requirements.*
Convention on Biological Diversity (CBD)	Covers all biodiversity Provides general principles for access and benefit-sharing concerning materials accessed after the coming into force of the CBD, yet not covered by the International Treaty on PGRFA (i.e. non-multilateral and non-CGIAR PGRFA).	Legally binding for countries that have ratified (183 as of March 2002) As for above, ratifying countries must adopt appropriate legislation/ regulations and/or bring existing ones into harmony with the Convention Convention does not apply to non-ratifying countries.
International Plant Protection Convention	Addresses phytosanitary issues with the transfer of plants and animals, including PGRFA.	Legally binding for the 113 countries that are party to the Convention.

Table 1.1. (cont.)

Law or Policy	**Topic / Applicability**	**Status / Jurisdiction**
International Undertaking on Plant Genetic Resources (IU)	Covered all PGRFA Addressed the exploration, preservation, evaluation and the making available of PGRFA.	113 countries adhered to the IU, which was adopted at FAO in 1983 Provisions of the IU were always voluntary—it was a non-binding agreement IU was renegotiated, resulting in the ITPGRFA, thus IU is superceded by the Treaty *Note: FAO–CGIAR "in trust" agreements refer to the IU, thus certain portions of the IU are still relevant in the context of the FAO–CGIAR agreements.*
WTO–TRIPS Agreement	Member States must comply with minimum standards of protection of IP Must ensure protection of microorganisms, non-biological and microbiological processes and plant varieties that meet protection criteria	Entered into force January 1995 Marrakech Ministerial Meeting in April 1994 Legally binding on all WTO Members Has possibility for trade sanctions for those found not in compliance.
UPOV (Plant Breeders' Rights)	UPOV aims to maximize plant breeding efforts by providing a model for securing protection under UPOV for plant breeders' rights for plant varieties.	Four versions; only 1991 is still open for joining Legally binding on 50 Parties to the Treaty.
Regional agreements (e.g. Andean Pact)	Coordinated laws/policies exist regarding some PGRFA-related topics, through the EU (biotech, patenting) and the Andean Pact (access).	Apply only to member countries.
Network agreements	Networks exist at both the regional and crop levels. Virtually all regions have multiple, regional/subregional networks. Some have crop working groups. Crop networks relate to conservation, genetic resource transfer and breeding / improvement, and function for a wide array of crops, at the regional and supraregional levels. See FAO's State of the World's Plant Genetic Resources (1998) for a listing and description.	Agreements apply to the contracting parties, be they states or institutions *Note: Neither the CBD nor the ITPGFRA specifies how it relates to particular network agreements between states. In such cases, the Vienna Convention on the Law of Treaties may be relevant. However, this Treaty provides no guidance in cases where states are party to one agreement but not the other*

Table 1.1. (cont.)

Law or Policy	Topic / Applicability	Status / Jurisdiction
Network agreements (cont.)	FAO (through the International Undertaking) has an international network of *ex situ* collections. The FAO Commission on Genetic Resources oversees and sets policies for the network *per se*. SADC and Nordic regions have centralized germplasm storage and agreements covering ownership and transfer of these materials. There are some NGO networks dealing with conservation and farmer participatory crop improvement. There are also joint country/ private sector projects (e.g. Latin American Maize Project) involving germplasm conservation and evaluation	*Note: The Coconut Genetic Resources Network (COGENT) is a formal member of the FAO's international network of* ex situ *collections.* NGO networks are typically informal or project-based; those involving the private sector are based on formal agreements or contracts.
National laws	National laws/regulations may address diverse topics such as conservation, use, access, benefit-sharing, farmers rights, quarantine, seed marketing standards, intellectual property rights.	Apply only to the individual country[a] *Note: national laws/regulations may be required to meet international treaty obligations. In addition, existing laws/ regulations may need to be altered to bring them into harmony with international treaties, post-ratification.*
FAO–CGIAR Agreements Placing Collections under the Auspices of FAO Associated documents/ instruments include: (a) 2 Joint FAO–CGIAR statements on the Agreement; (b) standard Material Transfer Agreement (MTA)	Agreements apply to the management, availability and transfer of specifically designated germplasm Joint statements address concern the practical implementation of the agreement; the agreed MTA (which has the force of a binding contract on recipients) is used in the transfer of designated germplasm.	11 Centres (those having *ex situ* collections) have signed binding agreements with FAO Agreements were foreseen as interim, pending the coming into force of the ITPGRFA; thus, the Treaty's Governing Body and the Centres will develop new agreements in line with Article 15 of the Treaty. Until then, current agreements apply.

Table 1.1. (cont.)

Law or Policy	Topic / Applicability	Status / Jurisdiction
FAO Global Plan of Action	Scope: all PGRFA Contains specific "activities" on *in situ* conservation and development, *ex situ* conservation, utilization, and institutions and capacity-building.	Adopted in 1996 by the 4th Intl Technical Conference on PGRFA (150 countries) Legally non-binding Serves as a framework, guide and catalyst for PGRFA efforts Is referenced in the ITPGRFA, and thus has a bearing on and a relation to a legally binding agreement.
FAO–IPGRI Genebank Standards	Sets out recommended genebank storage standards for seeds of orthodox species only.	Recommended by FAO and IPGRI to be used as the reference in national, regional and international genebanks Endorsed by the FAO Commission on Plant Genetic Resources in 1993 Not legally binding *Note: both FAO and IPGRI have published other "standards" in the past,* inter alia *on design of genebanks, germination, information handling, regeneration and multiplication, as well as descriptor lists.*
FAO Code of Conduct for Plant Germplasm Collecting and Transfer	Deals with the etiquette of collecting and transfer of PGRFA Has provisions on collectors' permits, responsibilities of collectors, sponsors, curators and users, as well as on reporting, monitoring and evaluating observance of the Code.	Adopted by FAO Conference in 1993 Not legally binding *Note: both the ITPGRFA and the CBD have provisions that add to or modify the guidance provided by the Code.*
CGIAR policies/ instruments	Policy on steps to be taken to implement the MTA (pertains only to germplasm designated under the agreements with FAO) Guidelines for germplasm acquisition Guidelines for designation of accessions under the FAO agreements Model MTA for non-plant genetic materials	Not legally binding Apply only to the CGIAR *Note: some of the policies and instruments are related to the FAO–CGIAR agreements and specify actions that must be taken by centres to meet these contractual obligations. With the coming into force of the International Treaty on PGRFA, some of these will need to be modified (e.g. the MTA), while some will become inoperable (e.g. guidelines for designation).*

CGIAR policies/ instruments (cont.)	Guidelines for acquisition and transfer of germplasm: micro-organism, animal and aquatic and marine
	Ethical principles relating to genetic resources
	Guiding principles on intellectual property rights
	Principles involving centre interaction with the private sector
	Position statements on biotechnology, the FAO–CGIAR agreements, "genetic use restriction technologies," and on the need to resolve certain issues concerning IPRs and genetic resources.

[a] Though contractual provisions or conflict of laws in contractual disputes may cause de facto territorial effect.

II. History and development

"Behind the politics and profits is a history which begins with the hunters and gatherers of twelve thousand years ago and runs to the gene-splicers of today."[1]

The evolution of law and policy

Legal regimes evolve over time in response to changing situations and needs. These changes are often catalyzed by scientific breakthroughs and technological advances. In the history of law there is also a close relationship between the recognition of the economic and commercial value of a resource and the attribution and allocation of legal entitlements.[2]

It is through the historical context that one learns the factors and circumstances that have affected the evolution of law and policy in a given field. The struggle over issues of sovereignty, control and ownership of genetic resources dates back hundreds if not thousands of years. The manifestation of that struggle in real and legal terms is a reflection of the capabilities and atmosphere of the time in which the struggle took place. Growth of scientific knowledge and technological capacity, and different interests, can catalyze change in legal regimes. Legal regimes can also be a reflection in time of the power of various actors. In sum, legal regimes are not stable, but dynamic systems.

It is therefore not surprising that the legal regimes governing issues of ownership and exchange of genetic resources have not been static. In the world economy today, extracted natural resources are treated as commodities. These resources cannot be collected without agreement of the State under whom jurisdiction the resource falls. Until recently, a notable exception to this was plant genetic resources which were accessed under the theory that the resources were part of the common heritage of humankind. This was partially because of the dual nature of plant genetic resources as both a commodity and a source of information. It is relatively easy to take or to smuggle a handful of seeds or samples out of a country[3] and under a common heritage regime there was no recourse in international law for the use of the resource as a source of information once the resource left the source State's jurisdiction.[4] Recently, however, technological advances—particularly with molecular biology and genetic engineering—have led to an ability to define and capture economic value in the genetic resources as a source of information. The laws and policies established in essence by physical might a few thousand years ago and still largely reflected in the practice of the colonial powers in the 18th and 19th centuries have given way to more political and diplomatic forms of confrontation. Intellectual property rights on or of relevance to genetic resources have been granted and their scope continues to grow. As the interest in genetic resources has grown more diverse—trade, environment, and development interests all come into play—so too has the conflict or potential conflict among different legal regimes with an impact on these resources.

What history teaches is that legal regimes respond to changing circumstances and are therefore inherently unstable. In the context of plant genetic resources, history illustrates that technological and scientific breakthroughs change the nature of the conflicts over rights and responsibilities and that legal regimes governing the resources respond and evolve accordingly. In a field where so many factors interplay, PGR managers should not expect a legal regime to solve a conflict "once and for all". The historical context of current laws, policies and controversies with regard to genetic resources provides a foundation to understand why things are the way they are and the opportunities and obstacles for their evolution in ways that are supportive of the conservation, sustainable use and sound management of genetic resources.

Historical exchange

Historically, plant genetic resources were relatively freely exchanged[5] in accordance with the idea that these resources were the common heritage of humankind.[6] Beginning

with the Age of Exploration, explorers took discovered plant species back to their own countries as new foods and raw materials for plant breeding.[7] The movement of plant genetic resources between Europe and the colonies supported expansion and changed civilizations.[8] The Great Columbian Exchange brought the tomato to Italy, maize to Africa, wheat to Latin America and the potato to Ireland and whole populations became dependent on exotic germplasm.[9]

"[C]ontrol over plants often meant much wealth and power."[10] Almost 3500 years ago, the first of the Pharaohs, Queen Hatshepsut, dispatched her military in an attempt to collect valuable plants and to resolve any differences of opinion over ownership there might be at the same time.[11] In colonial times, European powers laid claim to various plant species of economic importance such as sugar, tea, rubber, chinchona and indigo.[12] Without much lasting success, they tried to enforce their ownership, often through removal, isolation, and defense of production sites.[13]

Famine and the Green Revolution: the 1960s and early 1970s

Motivated by the twin goals of research facilitation and conservation, national and international efforts to collect, evaluate and conserve PGR increased during the 1960s.[14] Originally, the goal of facilitating research was to be achieved by centralizing stores of germplasm in genebanks accessible to all rather than by having them haphazardly stored in various jurisdictions around the world.[15] The second incentive recognized the need to conserve the genetic information upon which the development of newer and better crops depended.

These international efforts catalyzed a dramatic change in world agriculture. What came to be known as the "Green Revolution" was instigated by the public sector and without the use of intellectual property rights in the late 1960s. It began with the development of a new set of high-yielding varieties that greatly increased agricultural production. The world food supply was dramatically increased and the plant breeder popularly regarded as the "father of the green revolution," Dr Norman Borlang, was awarded the Nobel Peace Prize for his efforts.[16]

The negative aspects of the Green Revolution are now viewed by some to outweigh its benefits. The high-yielding varieties have been referred to by their detractors as "high-input" because of the high external inputs often required to maintain them. In addition, the push toward commercially mass-produced varieties led to the abandonment of diverse landraces. As one commentator states "The technological bind of improved varieties is that they eliminate the resource upon which they are based."[17] In 1967, a FAO technical conference proposed the creation of a global network of genebanks to store representative collections of the main varieties of food.[18] Priority was given to preserving the landraces, many of which were immediately threatened.[19]

The effects of the Green Revolution and in particular the problem of crop uniformity were experienced in very real terms in the 1970s with the corn blight in the United States and the failure of Besostaja, a high-yielding wheat planted almost exclusively in the Ukraine during the harsh winter of 1971–72. Spurred by the epidemics of the early 1970s,[20] collecting missions were mounted, genebanks established and institutions created in an atmosphere of crisis. In 1971, the FAO, the World Bank and the United Nations Development Programme founded the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an association of public and private donors that supports a network of 16 international research centres (IARCs) each with its own governing body.[21] With a budget of approximately US$328 million per annum, the CGIAR oversees the largest agricultural research effort in the developing world. The CGIAR conserves approximately

600 000 seed samples which may amount to as much as 40% of the world's unique germplasm in storage worldwide. There is no dispute that the vast majority of crop germplasm held in the IARCs was collected primarily from the fields and forests of the South's farming communities.[22] But to whom the resources ultimately belong, to whom the CGIAR is accountable, and whether or not the CGIAR germplasm can be subject to intellectual property protection by any party, were topics of controversy and debate and these issues were central in the negotiations for the International Treaty for Plant Genetic Resources for Food and Agriculture. As Chapter 4 describes, the IT has brought clarity to these issues.

The 1970s–1990s: ownership, rights and equity

Over the last 20 years or so, spurred by technological advances—particularly with molecular biology and genetic engineering—appreciation of the monetary and non-monetary value of genetic resources has grown, leading to increasing conflict over rights and responsibilities for these resources. The current international debate on legal regimes for plant genetic resources has its origins in the late 1970s and early 1980s when developing countries became concerned over the actions by the plant breeding industry in industrialized countries to extend intellectual property rights over "improved" varieties. The concern focused in particular on the inequity of continuing the historically free flow of germplasm which was seen as following a predominantly developing country to industrialized country pathway. During this same period efforts to collect and conserve PGR in genebanks heightened and the UPOV Convention (see below) was amended to admit non-European members. This led to expanded international cooperation in the recognition of plant-related intellectual property rights. These events resulted in even greater attention being paid to questions of PGR ownership in various fora.

The Food and Agriculture Organization

The Food and Agriculture Organization of the United Nations responded in 1983 by establishing the Global System for the Conservation and Utilization of Plant Genetic Resources. A Commission on Plant Genetic Resources was created to oversee the Global System.[23] The negotiation of an International Undertaking on Plant Genetic Resources was undertaken under the auspices of the Commission. Governments debated the ownership and control of PGR in a highly politicized environment concerned with intellectual property rights being granted for plant breeders' and national germplasm embargoes.[24] The acrimonious debate on the access, ownership and control of PGR that ensued during the adoption of the IU and its further refinement was dubbed the "seed wars" by the *Wall Street Journal*.[25]

In contrast to the position to be taken less than a decade later at the CBD negotiations, during these negotiations, developing countries pushed and succeeded in reflecting in the IU a broader reflection of the common heritage concept. The concept, however, was to apply not just to the PGR situated in developing countries but to the PGR subject to plant breeders' rights contained primarily by industry in developed countries. In the resolution by which the IU was adopted, Member States recognized that "plant genetic resources are a heritage of mankind to be preserved, and to be freely available for use, for the benefit of present and future generations." The IU made clear that this open availability was to apply to all PGR, including "special genetic stocks" which was interpreted broadly to include the specially bred proprietary lines of seed breeders.[26]

The initial rejection of the relatively recently developed plant-related intellectual property rights regimes is what made the IU controversial to the seed industry and hence to governments of the industrialized world. Denmark, Finland, France, New Zealand, Norway, Sweden, the United Kingdom and

the United States officially indicated their unwillingness to support the IU.[27]

In the 10 years after its adoption, the IU evolved through interpretive resolutions to reflect the growing acceptance of the need to accommodate plant breeders' rights to attract developed country interest. Because of that accommodation, the assertion of national sovereignty over PGR became the mechanism through which developing countries sought to correct the asymmetry of benefits accruing to developed and developing countries from PGR. Three interpretive resolutions were adopted. The first provided an agreed interpretation which recognized that plant breeders' rights were not necessarily inconsistent with the IU.[28] It also recognized Farmers' Rights and defined them in a second resolution as "rights arising from past, present and future contributions of farmers in conserving, improving and making available plant genetic resources, particularly those in the centres of origin/diversity."[29]

The emergence of the concept of Farmers' Rights was motivated more as part of a political effort to right the perceived imbalance created by the growing use and expansion of plant breeders' rights than as a legal concept or a property right. The countries agreed that Farmers' Rights would be recognized through an international fund, a fund that was never operationalized.

From the mid-1990s the Commission began a negotiating process to revise the IU to bring it into harmony with the Convention on Biological Diversity. The IT, which is dealt with in detail in Chapter 4, was adopted by consensus in November 2001.

The Convention on Biological Diversity

The Convention on Biological Diversity was conceived in the 1980s , affected by the same climate that catalyzed the interpretive resolutions to the IU. Unlike the IU, which was negotiated under the auspices of the FAO Commission, the CBD was negotiated under the leadership of the United Nations Environment Programme. The negotiators for the CBD by and large came from the Ministries of Environment represented at UNEP and not the Ministries of Agriculture represented at the FAO. In general terms, the CBD's origins can be classified into categories corresponding to its three objectives. One major source was conservationist concerns that existing international law for protection of wildlife was a patchwork that covered only selected issues, areas and species. They called for a more general agreement that would embrace a broader concept of nature and its value—including the full diversity of life at the level of genes, species and ecosystems—and protect the many elements of biodiversity not covered by existing laws. Second, there was a move to incorporate the goal of sustainable use of biological resources into conservation policy, recognizing the need of local people living amidst biodiversity for sustainable development, and conversely the need to mobilize support for conservation by providing local benefits. Third, international debate on the terms for exchanging and for sharing benefits from plant genetic resources for use in agriculture created pressure to include in the treaty obligations on these issues. Ironically, some key issues relating to agrobiodiversity—such as the status of pre-CBD *ex situ* collections and Farmers' Rights—were left outstanding.

Those advocates for a conservation orientation to the treaty supported the view that these resources were a "common heritage of humankind." The governments of the biodiversity "rich" countries, however, successfully asserted their national sovereignty over their resources from the beginning of the negotiations. The expansion of intellectual property rights over biological resources led to the idea of Farmers' Rights and the reaffirmation of sovereignty in the interpretive resolutions to the IU. The negotiators to the CBD responded to the same dissatisfaction with imbalance caused by IPRs, by reaffirming their sovereign rights over their own biological resources and by establishing that States have the authority

to determine access to genetic resources under their jurisdiction.

The issues of sovereignty and responsibility were most graphically displayed in discussions surrounding the questions of access to genetic resources and access to technology. The provisions on access affect the economic interests of all countries because all are interdependent when it comes to PGRFA whether it serves as a resource base for the life sciences and associated industry and/or underpins local food security. The assertions of sovereignty are most visible in Article 15 *Access to Genetic Resources*. Article 15 ultimately became a balancing act between traditional notions of sovereignty and the desire to ensure that access not become so cumbersome so as to make it effectively impossible. Despite its recognition elsewhere of a common concern for biodiversity loss, the Convention's provisions on access to genetic resources reaffirm national sovereignty over these natural resources and hence national authority to regulate access to genetic resources under a state's jurisdiction.

The issue of IPR and biodiversity was also very controversial during the negotiations for the CBD. Article 16 *Access to and Transfer of Technology* has the only explicit reference to intellectual property rights. Perhaps as a testimony to its ambiguity, the biotechnology industry has worried that the protection is too weak[30] while some civil society organizations claim the language is too strong. The final paragraph of that Article makes clear that the negotiators of the treaty were unable to reach consensus on the role of IPRs in the conservation and use of biodiversity. The gist of that provision is that Parties are to make sure that IPRs are supportive of the Treaty's objectives.[31]

Intellectual Property Rights: national and international trends

The application of modern biotechnologies to biomaterials has brought new economic opportunities and the growth and subsequent consolidation of industry concerned with bioindustrial products. It has also brought new challenges to existing IP regimes. Driven by the private sector, the trend in industrialized countries has been toward the expansion of the scope and/or application of patents and plant breeders' rights to biomaterials. The last 20 years have been characterized by the increasing consolidation of industry involved with bioindustrial products. By 1996, the world's top 10 agrochemical corporations accounted for 82% of global agrochemical sales; the top 10 seed companies controlled approximately 40% of the commercial seed market; the top 10 pharmaceutical companies accounted for 36% of global drug sales.[32] Many firms are dominant actors in all of these categories.[33] Figures disaggregated by crop show the concentration to be even higher. Both firm consolidation and IP expansion enhance market power.

Mirroring larger trends in globalization and consolidation of world markets, many private sector interests, national governments and intergovernmental organizations are making concerted efforts to "harmonize" IPRs—to gain some semblance of cohesion in a field that is in flux. The TRIPS Agreement and the evolution of the International Union for the Protection of New Varieties of Plants (UPOV) reflect these efforts.

The TRIPS Agreement is innovative from both a trade and intellectual property perspective. From the trade perspective, the TRIPS Agreement embodies the relatively novel and counterintuitive notion that trade *restrictions*, such as embargoes on "counterfeit" goods that imitate copyrighted or trademarked products, are necessary to promote trade *liberalization* and the lack of IPRS (which can create monopoly rights) is a restriction on trade.[34] Intellectual property had previously been seen as a domestic policy to be tailored to fit a country's level of development and technological goals, not as a matter of trade policy. One practical reason for this change is that developed countries, such as

the United States, wished to add intellectual property (IP) to the issues on the table in the Uruguay Round in order to achieve negotiating gains in their goals through trade-offs with other goals of interest to developing countries such as reductions in barriers to textile imports. The United States had previously had little success in gaining its IP goals within the World Intellectual Property Rights Organization (WIPO, see discussion below) where such trade-offs were impossible.

The original impetus for creating UPOV came from three organizations: a commercial plant breeders' trade association formed to promote plant variety protection, an organization with a mandate to promote industrial patents, and the International Chamber of Commerce. Six countries from Western Europe founded UPOV.[35] As discussed in more detail in Chapter 7, UPOV encourages the adoption of *sui generis* laws for protecting new plant varieties by creating its own distinct system outside of patent law. The growth of biotechnology and the possibility of formal patent coverage created the pressure leading to the 1991 revision. What is important to note here is the trend in the revision of UPOV—there are four versions, only the most recent of which is open to new members—is toward a strengthening of the rights granted.

Developments within WIPO, an intergovernmental organization established in 1967 to promote intellectual property rights worldwide, can be understood only in relation to these global trends. WIPO was essentially sidelined for what was probably the single biggest step in strengthening international IPR standards, the negotiation of the TRIPS Agreement. This was in large part due to a deliberate move by IPR proponents who anticipated making greater gains on IPR through negotiated trade-offs within the Uruguay Round, and also sought to strengthen enforcement of IPR standards by making it possible to enforce them through the WTO dispute-settlement procedures.[36]

Until recently, WIPO tended to avoid addressing issues relating to indigenous or traditional knowledge or to genetic resources. For example, WIPO rarely sent representatives to meetings of the CBD or FAO Commission on Plant Genetic Resources for Food and Agriculture. This has been changing over the last five or so years as the member States recognize the challenge of developing national legislation to implement the far-reaching requirements of TRIPS including the need for technical assistance,[37] and the potential role that WIPO can play in broadening the debate on IPR and relating it more clearly with equity issues. Dr Kamil Idris, appointed in fall 1997 as the organization's first new Director General in 25 years, has signalled an openness to exploring how WIPO can contribute its technical expertise and resources to the exploration of these issues. In March 1998, the WIPO General Assembly approved a reinvigorated programme for the Global International Property Issues Division that would address biodiversity, human rights and indigenous rights issues through activities such as research, publication and consultations. WIPO has also established an Intergovernmental Committee on Intellectual Property Rights, Genetic Resources, Traditional Knowledge and Folklore.

Given the rapid pace of technological advancements in genetics and biology, it is not surprising that biological subject matter challenges the legal parameters of ownership and control. Scientists are creating artificial human chromosomes, sequencing the entire genomes of living organisms, and cloning mammals to produce human proteins in their milk. Society is struggling with the social, ethical and legal implications of humankind's ability to control the genetic blueprint of life. Opinions differ sharply on the implications of new biotechnologies, but nearly everyone agrees that advances in technology are taking place at a rate far faster than social policies can be devised to guide them, or legal systems can evolve to address them. As Chapters 7 and 8 discussing

the relevant provisions of TRIPS and UPOV and Chapter 10 on the development and improvement of genetic resources illustrate, whether the subject is plant breeders' rights or plant and animal patenting, there is little consensus on the potential impacts of intellectual property on biodiversity, food security and development. Despite concerted efforts to achieve harmony and consistency across national and regional borders, intellectual property as it applies to biomaterials continues to be controversial and characterized by confusion and uncertainty.

Endnotes

1 Fowler, Cary and Pat Mooney. 1990. Shattering. Food, Politics, and the Loss of Genetic Diversity. Univ. of Arizona Press.

2 Cottier, Thomas. 1998. The protection of genetic resources and traditional knowledge: towards more specific rights and obligations in world trade law. J. Interl Econ. Law 555-582.

3 Thomas Jefferson reported smuggling upland rice seed out of Italy in the linings of his coat in an attempt to introduce it and encourage its cultivation in South Carolina. According to Mr Jefferson's accounts, the farmers of South Carolina rejected the Italian seed believing their rice to be superior. *See* Cary Fowler. 1994. Unnatural Selection: Technology, Politics and Plant Evolution. Gordon and Breach Science Publishers, Switzerland, p. 14 (citing Thomas Jefferson. 1944. *Thomas Jefferson: Garden Book*, edited by Edwin Morris Betts. The American Philosophical Society, Philadelphia, pp. 124–131).

4 So in 1755 when Pierre Poivre smuggled pepper and cinnamon to Ile de France and broke the Dutch spice monopoly, he found himself ennobled by the French king. Brockway, Lucile H. 1988. Plant science and colonial expansion: the botanical chess game. P. 54 *in* Seeds and Sovereignty: The Use and Control of Plant Genetic Resources (J.R. Kloppenburg, ed.). Duke University Press, London.

5 It should be noted that there are historical examples of specific governmental rules restricting the export of certain specialized and industrial breeding materials such as pepper from India, oil palm from Malaysia, coffee from Ethiopia and tea from Sri Lanka. *See* Agricultural Crop Issues and Policies. Chapter on Proprietary Rights, page 289. There was, however, no recourse when PGR was taken. (Klaus Bosselmann. 1996. Plant and Politics: The International Legal Regime Concerning Biotechnology and Biodiversity. Colo. J. Intl Envtl Law & Policy 7, p. 121.)

6 Cooper, David. 1993. The International Undertaking on Plant Genetic Resources. RECIEL 2:2, pp. 158-166; Harold J. Bordwin. 1985. The Legal and Political Implications of the International Undertaking on Plant Genetic Resources, Ecology L.Q. 12:1053.

7 Odek, James O. 1999. Bio-piracy: creating proprietary rights in plant genetic resources. J. Intell. Prop. Law 2:141. It was with the advent of the "Seed Wars" in the 1980s and the negotiation of the Convention on Biological Diversity that developing countries made clear that this practice was not acceptable and that legal mechanisms to formally support this position were sought.

8 Kloppenburg, Jack R. Jr. 1988. First the Seed. The Political Economy of Plant Biotechnology 1492-2000, pp. 153-157. Cambridge University Press, Cambridge, UK.

9 Ibid. citing Rebecca Margulies. 1993. Note, Protecting biodiversity: recognizing intellectual property rights in plant genetic resources. Mich. J. Intl. Law 14:322–356. The potato, native to the Andean people, was introduced to Ireland from Central Europe. Unfortunately, the Irish did not import enough genetic diversity to ensure crop stability during the great potato famine of the mid-1800s. The introduction of the potato facilitated a three-fold increase of the Irish population to 8 million people. When a previously unknown disease caused by a fungus wiped out the potato crop within 10 years, 2 million Irish people had died, 2 million had emigrated and 4 million remained, many living in terrible poverty.

10 Busch, Lawrence, W.B. Lacy, J. Burkhardt and L.R. Lacy. 1991. Plants, power and profit: social, economic and ethical consequences of the new biotechnologies. Blackwells, Cambridge, MA, USA. *See also* Brockway, Lucile H. 1988. Plant science and colonial expansion: the botanical chess game. P. 49 *in* Seeds and Sovereignty: The Use and Control of Plant Genetic Resources (J.R. Kloppenburg, ed.). Duke University Press, London.

11 Farney, Dennis. 1980. "Meet the men who risked their lives to find new plants." Smithsonian, June, 1980.

12 Crosby, Alfred. 1986. Ecological Imperialism: The Biological Expansion of Europe, 900-1900. Cambridge University Press, Cambridge, UK.

13 Ibid.

[14] Plucknett, D.L. *et al.* 1983. Crop germplasm and developing countries. Science 163:220.
[15] Tilford, David S. 1998. Saving the blueprints: the international legal regime for plant resources. 30 Case W. Res. J. Intl 373:389.
[16] Ibid., p. 391.
[17] Kloppenburg, Jack R. Jr. 1988. First the Seed. The Political Economy of Plant Biotechnology 1492-2000, pp. 162. Cambridge University Press, Cambridge, UK.
[18] Frankel, O.H. 1986. Genetic resources: The founding years. II. The movement's constituent assembly. Diversity 9:30-32.
[19] Wilkes, H. Garrison. 1988. Plant genetic resources over ten thousand years: from a handful of seed to the crop-specific mega-genebanks. Pp. 67-79 *in* Seeds and Sovereignty: The Use and Control of Plant Genetic Resources (Jack R. Kloppenburg, ed.). Duke University Press, London.
[20] Crop uniformity was one factor in the epidemics. Other factors also were important, including, for example, the international oil crisis and the Sahelian drought.
[21] Four of the centres were established prior to the formation of the CGIAR.
[22] Bragdon, Susan H. and David Downes. 1998. Recent policy trends and developments related to the conservation, use and development of genetic resources. Issues in Genetic Resources No. 7, p 17. International Plant Genetic Resources Institute, Rome, Italy.
[23] As of 23 August 1999, the Commission had 160 state members plus the European Community.
[24] Mooney, P.R. 1983. The law of the seed: another development and plant genetic resources. Development Dialogue I-2:7-172.
[25] Kloppenburg, Jack R. Jr and Daniel Lee Kleinman. 1988. Plant genetic resources: the common bowl. Pp. 1–2 *in* Seeds and Sovereignty: The Use and Control of Plant Genetic Resources (Jack R. Kloppenburg, ed.). Duke University Press, London.
[26] International Undertaking, *supra* Note 7, Article 2.
[27] Tilford, *see* Endnote 15, *supra* at no. 251.
[28] FAO Conference Resolution C4/89, 1989.
[29] FAO Conference Resolution C5/89, 1989.
[30] The Industrial Biotechnology Association (IBA) and the Association of Biotechnology Companies (ABC) to oppose US approval of the Convention. Reginald Rhein, Biological Diversity Convention Would Limit Patent Rights, Says IBA, 12 BIOTECH. NEWSWATCH 1 (18 May 1992). The President and CEO of Genetech, G. Kirk Rabe, wrote to President Bush before his departure to Rio where the CBD would be signed saying "the proposed Convention runs a chance of eroding the progress made in protecting American intellectual property rights" Hamilton, Neil. 1993. Who owns dinner: evolving legal mechanisms for ownership of plant genetic resources. 28 Tulsa L.J. 587–646. *supra* at 623 (citing Steve Usd. 1992. Biotech Industry Played Key Role in U.S. Refusal to Sign BioConvention, Diversity 8(2):8.) President Clinton signed the treaty the day before it closed for signature with the support of the biotechnology industry with the promise that it would be sent to the Senate to consider ratification with an interpretive statement alleviating their intellectual property concerns.
[31] Quote Article 16.5.
[32] RAFI. 1997. Life Industry. RAFI Communique, November/December 1997.
[33] Examples of major life industry firms include Sygenta, Novartis, Monsanto and DuPont.
[34] Downes, David. 1997. Using Intellectual Property as a Tool to Protect Traditional Knowledge: Recommendations for Next Steps: CIEL Discussion Paper prepared for the Convention on Biological Diversity Workshop on Traditional Knowledge, Madrid, November 1997. CIEL, Washington. Discussion draft, p. 6.
[35] Fowler, Cary. 1994. Unnatural Selection: Technology, Politics and Plant Evolution, pp. 104. Gordon and Breach Science Publishers, Switzerland.
[36] Jackson, John H. 1997. The World Trading System: Law and Policy of International Economic Relations. 2nd edition. The MIT Press, Cambridge, MA.
[37] WIPO, unlike the WTO, has decades of experience and considerable staff and other resources to support provision of technical assistance on national IP laws and institutions. Thus, WTO and WIPO have signed an agreement committing the two institutions to greater cooperation on matters such as information-sharing and technical assistance.

III. The FAO Global System for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture

The FAO Commission on Genetic Resources for Food and Agriculture

The 1983, the FAO Conference established the FAO Commission on Plant Genetic Resources, which was the first permanent intergovernmental forum in the United Nations system to deal with agricultural biological diversity. In 1995, its mandate was broadened to cover all components of biological diversity of interest to food and agriculture, when it became the Commission on Genetic Resources for Food and Agriculture. At present, 160 countries and the European Union are members of the Commission, which usually holds a regular meeting at two-year intervals, and extraordinary sessions as required. The Commission provides a forum for governments to discuss matters and negotiate agreements on all matters of common interest related to agrobiodiversity. It aims to reach international consensus on matters of global interest. The Commission reviews and advises FAO on its policy, programmes and activities related to the conservation, sustainable use and equitable sharing of benefits derived from the utilization of genetic resources of relevance to food and agriculture. Relevant technical assistance agencies, intergovernmental organizations, development banks, non-governmental organizations and private foundations also attend the sessions of the Commission, and report to it on their programmes and activities on genetic resources for food and agriculture.

Development of the FAO Global System

The Commission's terms of reference specify that it will "recommend such measures as may be necessary or desirable to ensure the development, as appropriate, of a comprehensive global system or systems on genetic resources of relevance to food and agriculture and to monitor the operation of its/their components, in harmony, where applicable, with the Convention on Biological Diversity and other relevant international instruments".[1]

Throughout the years, the Commission has accordingly coordinated, overseen and monitored the development of a Global System for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. The objectives of the Global System are to ensure the safe conservation and promote the availability and sustainable utilization of plant genetic resources, for present and future generations, by providing a flexible framework for sharing the benefits and burdens. The System covers both the conservation of plant genetic resources (*ex situ* and *in situ*, including on-farm) and their sustainable utilization. The Global System contains a number of elements, as shown in Figure 3.1.

The International Undertaking on Plant Genetic Resources for Food and Agriculture

The keystone of the Global System has been the International Undertaking on Plant Genetic Resources for Food and Agriculture, which was adopted by a resolution of the 1983 FAO Conference, and interpreted and complemented by three further Conference resolutions, in 1989 and 1991. The International Undertaking was the first comprehensive international agreement dealing with plant genetic resources for food and agriculture. It promotes international harmony in matters regarding PGRFA. One hundred and thirteen countries have adhered to the Undertaking, which seeks to "ensure that plant genetic resources of economic and/or social interest, particularly for agriculture, will be explored, preserved, evaluated and made available for plant breeding and scientific purposes".

In 1992, Agenda 21 called for the strengthening of the FAO Global System on Plant Genetic Resources, and its adjustment in line with the outcome of negotiations on the Convention on Biological Diversity. In 1993, the FAO Conference accordingly requested FAO to provide a forum in the FAO Commission on Genetic Resources for Food and

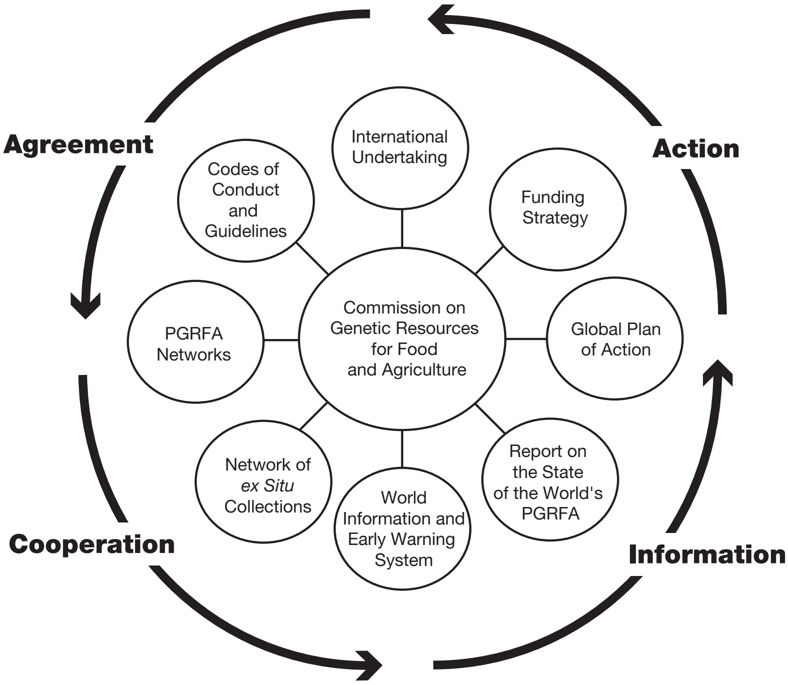

Fig. 3.1. The Global System for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.

Agriculture, for negotiation among governments, for:

- the revision of the International Undertaking on Plant Genetic Resources, in harmony with the Convention on Biological Diversity
- consideration of the issue of access on mutually agreed terms to plant genetic resources, including *ex situ* collections not addressed by the Convention on Biological Diversity
- the issue of the realization of Farmers' Rights.

Adoption of the International Treaty on Plant Genetic Resources for Food and Agriculture

The negotiations for the revision of the Undertaking started, in November 1994, at the first extraordinary session of the Commission on Plant Genetic Resources. They continued until, on 3 November 2001, the Thirty-first FAO Conference adopted the International Treaty on Plant Genetic Resources for Food and Agriculture, by unanimity.[2]

The International Treaty will enter into force after ratification by 40 countries, when a Governing Body, composed of all Contracting Parties to the Treaty, will be convened. Until then, the FAO Commission on Genetic Resources for Food and Agriculture will act as the Interim Committee for the Treaty, and will oversee a number of tasks to be undertaken in the interim period.

The International Treaty will then supersede the International Undertaking, including in relation to the *ex situ* collections of plant genetic resources for food and agriculture held in trust by the International Agricultural Research Centres of the Consultative Group on International Agricultural Research. Until then, the International Undertaking, under the

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

Is at the cross-roads between agriculture, trade and the environment. It provides agriculture with a new, legally binding instrument on a par with trade and environmental instruments, and promotes harmony and synergy across the sectors.

Covers all plant genetic resources relevant to food and agriculture. Its objectives are the conservation and sustainable use of plant genetic resources and the fair and equitable benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security. It aims at ensuring that the inherited capital they represent is conserved, and continues to supply the flow of services on which food security and development depend.

Establishes a Multilateral System of Access and Benefit-sharing for Plant Genetic Resources, for an agreed list of crops, established on the basis of interdependence and food security. The list currently covers 35 food crops, and 29 forage genera, representing more than 80% of the world's calorie intake. The genetic resources of these crops are pooled. The country of origin cannot therefore be the basis of benefit-sharing, which means that the benefits must also be shared on a multilateral, rather than on a bilateral basis.

Provides for benefit-sharing through information exchange, technology transfer, capacity-building, and the mandatory sharing of the monetary and other benefits of the commercialization of products incorporating material accessed from the Multilateral System. The primary focus is on farmers in the developing world, who conserve and sustainably utilize plant genetic resources for food and agriculture.

Includes a Funding Strategy to mobilize funding for priority activities, plans and programmes, in particular in developing countries and countries with economies in transition, taking into account the Global Plan of Action adopted in Leipzig in 1996.

Provides for the realization of Farmers' Rights by national governments through:
- the protection of relevant traditional knowledge
- equitable participation in sharing benefits derived from the use of PGRFA
- participation in national decision-making related to their conservation and sustainable use.

aegis of the FAO Commission on Genetic Resources for Food and Agriculture, is the governing agreement.

The International Network of *ex situ* collections under the auspices of FAO

The Commission called for the development of the International Network in 1989, in line with Article 7.1(a) of the International Undertaking, because of uncertainty regarding the legal situation of *ex situ* germplasm in genebanks, and of the lack of appropriate agreements to ensure its safe conservation. Moreover, the provisions regarding access to genetic resources in the Convention on Biological Diversity (Article 15) do not apply to *ex situ* collections assembled prior to its entry into force.

Twelve International Agricultural Research Centres of the Consultative Group on International Agricultural Research accordingly signed agreements with FAO in 1994, placing most of their collections (some 500 000 accessions) in the International Network. Through these agreements, the Centres recognized the "intergovernmental authority of FAO and its Commission in setting policies for the International Network". They accept, in particular, to hold designated germplasm "in trust for the benefit of the international community" and "not to claim ownership, or seek intellectual property rights over the designated germplasm and related information". In releasing these materials, the Centres pass the same obligations on to the recipient, and all further recipients, by means of a standard Material Transfer Agreement approved by the Commission.

The regional collections of the International Coconut Genetic Resources Network (COGENT), held by the governments of India, Indonesia and Côte d'Ivoire, have also been brought into the Network since October 1998, through agreements signed between FAO, the host countries on behalf of their respective regions, and the International Plant Genetic Resources Institute, on behalf of COGENT.

The Commission noted that the final form of such agreements would depend upon the outcome of the negotiations for the revision of the International Undertaking. The International Treaty, in fact, specifically recognizes the importance to the Treaty of the *ex situ* collections of plant genetic resources for food and agriculture held in trust by the IARCs. Article 15 provides for agreements to be signed with them, and other relevant international institutions, with regard to their *ex situ* collections. Plant genetic resources for food and agriculture in the Treaty's Multilateral System will be distributed under the terms of a standard Material Transfer Agreement to be agreed by the Governing Body. Other plant genetic resources for food and agriculture, collected before the entry into force of the Treaty, will be distributed under the terms of another Material Transfer Agreement agreed by the Governing Body. This should help reduce international tensions around the transfer and use of plant genetic resources for food and agriculture, and facilitate collecting and exchange.

International Plant Genetic Resources Networks

The Commission has recognized that crop-related networks are a useful approach to integrating activities on plant genetic resources within the Global System, and to strengthening practical linkages between the conservation and sustainable utilization of crop genetic resources. FAO has therefore continued to support the establishment of global and regional crop-related networks, covering a large variety of cultivated species, in close collaboration with relevant scientific organizations. In recent years, the complementarity of *in situ* and *ex situ* strategies has been recognized. The Commission has therefore called for the establishment of networks of *in situ* conservation areas, which would include "on-farm" conservation of crops and *in situ* conservation of crop wild relatives.

The International Treaty encourages cooperation in international plant genetic resources for food and agriculture networks, on the basis of existing arrangements, so as to achieve as complete coverage as possible of plant genetic resources for food and agriculture. It states that the Contracting Parties will therefore encourage all relevant institutions, including governmental, private, non-governmental, research, breeding and other institutions, to participate in international networks.

The State of the World's Plant Genetic Resources for Food and Agriculture and The Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture

Two important policy document were produced in the context of the Leipzig

International Technical Conference on Plant Genetic Resources, which FAO convened in 1996: the first Report on the State of the World's Plant Genetic Resources for Food and Agriculture; and the rolling Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.

In 1989, the Commission recommended the preparation of a periodic Report on the State of the World's Plant Genetic Resources, which would analyze the current plant genetic resources situation, and describe activities and programmes being carried out by regional, international and non-governmental organizations, with the aim of identifying gaps, constraints and emergency situations. On this basis, the Commission could recommend priorities and ways of harmonizing the overall effort. The Commission also agreed that the needs, emergencies and priorities identified in the Report on the State of the World's Plant Genetic Resources would provide the basis for the operation and periodic updating of a Global Plan of Action.

In preparing for the Leipzig International Technical Conference, 158 governments prepared country reports, assessing the status of their plant genetic resources, and their capacity to conserve and utilize them: the first Report on the State of the World's Plant Genetic Resources is largely based on this information. The Report assesses the state of plant genetic diversity and capacities at local, national, regional and global levels, for *in situ* management, *ex situ* conservation and sustainable utilization. It identifies current gaps and needs and priorities, which are addressed in the Global Plan of Action. The International Technical Conference welcomed the Report as the first comprehensive worldwide assessment of the state of plant genetic resources conservation and use.

In 1991, the Commission also requested the preparation of a rolling Global Plan of Action on Plant Genetic Resources for Food and Agriculture, in order to identify the technical and financial needs for ensuring conservation and promoting sustainable use of plant genetic resources, with programmes and activities aimed at filling in gaps, overcoming constraints and facing emergency situations.

The Plan was developed under the guidance of the Commission, through a country-driven preparatory process that included 12 regional and subregional meetings at which governments discussed regional problems and opportunities and made recommendations for the Plan. This helped catalyze the formation and strengthening of national programmes and regional networks and promoted scientific cooperation. The Plan comprises 20 priority activities, covering *in situ* and *ex situ* conservation, plant genetic resources utilization, and institution and capacity-building. The implementation of the rolling Plan is monitored by the Commission on Genetic Resources for Food and Agriculture.

The Global Plan of Action was formally adopted by 150 countries at the Leipzig International Technical Conference. In adopting the Plan, Governments also adopted the Leipzig Declaration, through which they committed themselves to taking the necessary steps to implement the Global Plan of Action.

The International Treaty acknowledges that the conservation, exploration, collection, characterization, evaluation and documentation of plant genetic resources for food and agriculture are essential in meeting the goals of the Rome Declaration on World Food Security and the World Food Summit Plan of Action, and for sustainable agricultural development for this and future generations, and that the capacity of developing countries and countries with economies in transition to undertake such tasks needs urgently to be reinforced. It notes that the Global Plan of Action is an internationally agreed framework for such activities, and provides that Contracting Parties should promote the effective implementation of the rolling Global Plan of Action, including through national actions and international cooperation to

provide a coherent framework for capacity-building, technology transfer and exchange of information.

Funding Strategy

The International Treaty makes provision for a Funding Strategy, to enhance the availability, transparency, efficiency and effectiveness of the provision of financial resources to implement activities under the Treaty. An appropriate mechanism, such as a trust account, will be established for receiving and utilizing financial resources for purposes of implementing the Treaty.

In order to mobilize funding for priority activities, plans and programmes, in particular in developing countries and countries with economies in transition, and taking the Global Plan of Action into account, the Governing Body shall periodically establish a target for such funding. The Contracting Parties shall take the necessary and appropriate measures within the Governing Bodies of relevant international mechanisms, funds and bodies to ensure due priority and attention to the effective allocation of predictable and agreed resources for the implementation of plans and programmes under the Treaty. Developed country Parties provide financial resources for the implementation of the Treaty through bilateral and regional and multilateral channels, which developing country Parties and those with economies in transition may avail themselves of.

Also part of the financial strategy are the monetary benefits arising from the commercial use of plant genetic resources for food and agriculture from the Treaty's Multilateral System of Facilitated Access and Benefit-sharing. Someone who obtains a commercial profit from the use of these genetic resources is obliged, by a standard Material Transfer Agreement, to share these profits fairly and equitably, and pay an equitable royalty to a Fund overseen by the Treaty's Governing Body, as part of its funding strategy. Payment is mandatory on the commercialization of a product that is a plant genetic resource and that incorporates material accessed from the Multilateral System, when this product is not available without restriction to others for further research and breeding. It is voluntary when it is. At its first meeting, the Governing Body will determine the level, form and manner of the payment, in line with commercial practice. It may establish different levels of payment for various categories of recipients commercializing such products, and from time to time review the levels of payment.

Priority will be given to the implementation of agreed plans and programmes for farmers in developing countries, especially in least-developed countries, and in countries with economies in transition, who conserve and sustainably utilize plant genetic resources for food and agriculture.

The World Information and Early Warning System on PGR

Under the guidance of the Commission, FAO has established the World Information and Early Warning System, which collects, disseminates and facilitates the exchange of information that governments provide on plant genetic resources collections and related technologies. This is an important tool for the periodic updating of the Report on the State of the World's Plant Genetic Resources. Its databases contain data on: the location of over 5.5 million plant genetic resources accessions, in some 1410 *ex situ* collections around the world; the structure and activities of national plant genetic resources programmes in almost all countries; some 8000 seed-supplying institutions around the world; commercial crop varieties, and relevant non-FAO databases and how to obtain information from them. An Early Warning Mechanism is being developed to draw rapid attention to hazards threatening the operation of *ex situ* collections, and to the danger of the extinction of plant species and the loss of the genetic diversity of crops for food and agriculture.

The International Treaty also provides for the development and strengthening of a global information system to facilitate the exchange of information, based on existing information systems, on scientific, technical and environmental matters related to plant genetic resources for food and agriculture. This will also provide early warning about hazards that threaten the efficient maintenance of PGRFA.

Codes of Conduct and Guidelines

A number of Codes of Conduct and Guidelines have been negotiated under the aegis of the Commission on Genetic Resources for Food and Agriculture.

The *International Code of Conduct for Plant Germplasm Collecting and Transfer* was adopted by the FAO Conference in 1993. It provides a guide which governments may use until they develop their own national regulations.

A draft *Code of Conduct for Biotechnology as it relates to Genetic Resources for Food and Agriculture* was prepared at the request of the Commission and considered at its Fifth Session in 1993. The draft Code includes provisions to maximize the positive effects of biotechnology and minimize potentially negative effects of agrobiotechnologies. The Ninth Regular session of the Commission, in late 2002, will begin consideration of the draft.

FAO and the International Plant Genetic Resources Institute have, since 1989, jointly published *Technical Guidelines for the Safe Movement of Plant Germplasm*. The Commission has also agreed on a set of *Genebank standards*, jointly prepared by FAO and the International Plant Genetic Resources Institute.

Endnotes

1 Its terms of reference also state that the Commission "will facilitate and oversee cooperation between FAO and other international governmental and non-governmental bodies dealing with the conservation and sustainable use of genetic resources, in particular with the Conference of the Parties to the Convention on Biological Diversity and the UN Commission on Sustainable Development, and will seek to develop appropriate mechanisms for cooperation and coordination in consultation with such bodies.

2 With two abstentions: the USA and Japan.

IV. The International Treaty on Plant Genetic Resources for Food and Agriculture

Relevance to Genetic Resources professionals

"Access", "exchange" and "benefit-sharing" are important topics today to anyone concerned with management of plant genetic resources for food and agriculture. As this manual demonstrates, these topics are complex and are the subject of multiple treaties, national laws, regulations and policy.

In the future, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) will certainly be the most important international agreement in this field. Consequently, this manual devotes considerable attention to the Treaty, how it will work, and what its implications are for future management and policy-making.

"Access", "exchange" and "benefit-sharing" have also been complex and contentious issues for centuries, even millennia, thus the adoption of the first international treaty dealing with these difficult topics has to be an historic event and one that deserves our serious attention.

The FAO Conference adopted the International Treaty on Plant Genetic Resources for Food and Agriculture by consensus in November 2001. The stated objectives of the Treaty are 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…"

The Treaty contains 35 articles and 2 annexes. While the scope of the Treaty is comprehensive, covering all plant genetic resources for food and agriculture, readers will be particularly interested in the articles that establish a multilateral system of access and benefit-sharing for particular crops.

Although it has been adopted, the Treaty will not actually come into force until 90 days after the 40th instrument of ratification has been deposited with FAO. In most cases, ratification requires action by a country's parliament and/or executive. One might expect that for many countries this ratification process could take several years. When it comes into force, it will legally bind only those countries that have ratified it, plus those international institutions (such as CGIAR centres) that have entered into formal agreements with the Treaty's Governing Body to associate themselves with the Treaty.

What are the major changes the Treaty with bring?

- The Treaty should help reduce international tensions around the transfer and use of plant genetic resources for food and agriculture (PGRFA), and thus should facilitate collecting and exchange.
- Access to PGRFA of crops that are included within the Treaty's multilateral system should become routine and easy—"facilitated" in the language of the Treaty. Access to materials of other crops (including soyabean, groundnut, tomato, sugarcane, industrial crops and most tropical forages, to name some of the most important excluded crops) will likely be more difficult, requiring (as it does now) a specific agreement with the country providing the access. The concept of "designated" germplasm will be dropped, replaced by the new distinction between PGRFA of crops that are part of the multilateral system and those that are not. It will probably be necessary, nonetheless, to identify the materials covered, and particularly those of non-multilateral system crops. Facilitated access will be provided to materials of crops that are in the multilateral system, with the exception that there will be no obligation to provide materials "under development" during their period of development (*see* Section III. Access *and* B. Definitional issues).
- Access to PGRFA that is part of the multilateral system established by the Treaty will be provided under terms specified in a standard "Material Transfer Agreement" (MTA). This MTA, the wording of which will be agreed to by the Treaty's Governing Body, will bind the recipient of PGRFA (and subsequent recipients)

to certain benefit-sharing arrangements in particular defined circumstances (*see below* 'Benefit-sharing').

- Farmers' Rights, a contentious issue for more than a decade, is largely assigned to national governments for them to define and implement as they see fit.

Our assessment begins with Part IV of the Treaty, which establishes the multilateral system. Following this detailed examination of the articles on access and benefit-sharing, we will look at the scope of the Treaty (what crops and which materials it covers). Then, we will briefly describe the remaining elements of the Treaty, and conclude by identifying some of the ambiguities and problems contained in the Treaty.

The Multilateral System: access and benefit-sharing

Overview

The Treaty establishes a multilateral system with rules for access and benefit-sharing for genetic resources (of a defined list of crops) and associated information. Access is provided to *ex situ* and *in situ* materials, other than those under development during the period of development. The Treaty does not cover access for purposes that are not related to food and agriculture. Intellectual property rights (IPRs) are respected. IPRs may not be claimed, however, on material "in the form received" from the system. (Some uncertainty exists as to what that means, precisely.) PGRFA will be provided under the terms of a standard, yet-to-be-agreed Material Transfer Agreement to be used by Contracting Parties and CGIAR centres. Benefit-sharing in the form of a payment into an international fund at FAO will be mandatory when genetic material from the system is used to produce a "product that is a PGRFA" (e.g. a line or cultivar) that is commercialized, unless this product is made available without restriction for further research and development. In effect, patenting will trigger the benefit-sharing mechanism; plant breeders' rights probably will not.

Part IV of the Treaty is entitled "The Multilateral System of Access and Benefit-Sharing." Part IV contains Article 10, which establishes the multilateral system as well as specific articles on coverage, access and benefit-sharing. (As specified in Article 15 on the CGIAR collections, centres will also provide and obtain access to Annex I materials in accordance with the terms of Part IV of the Treaty.)

10.1 In their relationships with other States, the Contracting Parties recognize the sovereign rights of States over their own plant genetic resources for food and agriculture, including that the authority to determine access to those resources rests with national governments and is subject to national legislation.

10.2 In the exercise of their sovereign rights, the Contracting Parties agree to establish a multilateral system, which is efficient, effective and transparent, both to facilitate access to plant genetic resources for food and agriculture, and to share, in a fair and equitable way, the benefits arising from the utilization of these resources, on a complementary and mutually reinforcing basis.

Article 10 establishes the multilateral system. In this article, Contracting Parties[1] specifically assert that they are exercising their sovereign rights (as the Convention on Biological Diversity reaffirms that they have over their genetic resources) to establish this multilateral system. This article thus provides a link with the Convention, and makes clear

that the rules governing access and benefit-sharing for the multilateral system will be the "mutually agreed terms" referred to in the Convention.

Leaving aside for the moment Article 11 on coverage, we shall begin our detailed analysis with Article 12 which addresses the topic of access to PGRFA within the multilateral system—to materials of crops contained in Annex I. This article covers materials found in both *ex situ* and *in situ* conditions.

Access

12.1 The Contracting Parties agree that facilitated access to plant genetic resources for food and agriculture under the Multilateral System, as defined in Article 11, shall be in accordance with the provisions of this Treaty.

12.2 The Contracting Parties agree to take the necessary legal or other appropriate measures to provide such access to other Contracting Parties through the Multilateral System. To this effect, such access shall also be provided to legal and natural persons under the jurisdiction of any Contracting Party, subject to the provisions of Article 11.4.

12.3 Such access shall be provided in accordance with the conditions below:

12.3(a) Access shall be provided solely for the purpose of utilization and conservation for research, breeding and training for food and agriculture, provided that such purpose does not include chemical, pharmaceutical and/or other non-food/feed industrial uses. In the case of multiple-use crops (food and non-food), their importance for food security should be the determinant for their inclusion in the Multilateral System and availability for facilitated access.

Article 12.2 notes that facilitated access shall be provided to Contracting Parties, as well as to "legal and natural persons" under the jurisdiction of any Contracting Party. This means that access will be provided to individuals as well as to institutions or organizations that have a "legal personality", such as private companies, NGOs, etc.

Article 12.3 lays out the conditions under which facilitated access is granted. Specifically, it is granted for purposes that relate to food and agriculture. Access for other purposes (e.g. pharmaceutical, chemical) is not covered by this Treaty, meaning that those seeking access for such purposes will need to make separate arrangements. In most cases, such access will effectively fall under the framework of the Convention on Biological Diversity. Access may even be denied.

12.3(b) Access shall be accorded expeditiously, without the need to track individual accessions and free of charge, or, when a fee is charged, it shall not exceed the minimal cost involved;

12.3(c) All available passport data and, subject to applicable law, any other associated available non-confidential descriptive information, shall be made available with the plant genetic resources for food and agriculture provided;

12.3(d) Recipients shall not claim any intellectual property or other rights that limit the facilitated access to the plant genetic resources for food and agriculture, or their genetic parts or components, in the form received from the Multilateral System;

12.3(e) Access to plant genetic resources for food and agriculture under development, including material being developed by farmers, shall be at the discretion of its developer, during the period of its development;

12.3(f) Access to plant genetic resources for food and agriculture protected by intellectual and other property rights shall be consistent with relevant international agreements, and with relevant national laws;

12.3(g) Plant genetic resources for food and agriculture accessed under the Multilateral System and conserved shall continue to be made available to the Multilateral System by the recipients of those plant genetic resources for food and agriculture, under the terms of this Treaty; and

12.3(h) Without prejudice to the other provisions under this Article, the Contracting Parties agree that access to plant genetic resources for food and agriculture found in *in situ* conditions will be provided according to national legislation or, in the absence of such legislation, in accordance with such standards as may be set by the Governing Body.

Paragraphs 12.3(b) through (h) specify additional conditions under which access is provided and identify circumstances under which access might be denied legitimately.

Several of these paragraphs are critical to the workings of the multilateral system. In general, these paragraphs acknowledge the applicability of intellectual and other property rights over the material. They call for Contracting Parties to make available not just the genetic material, but also associated, descriptive (i.e. non-proprietary) information.

Paragraph (b) specifies that those providing genetic resources need not track individual accessions.

Paragraph (d) is a key one in trying to define the extent to which intellectual property rights can be applied to material accessed from the multilateral system. However it contains a number of ambiguities and is open to interpretation in part because key terms employed in this paragraph are not defined.

The phrase "intellectual property or other rights that limit the facilitated access to the plant genetic resources for food and agriculture" can be interpreted in two ways:

- that IPRs limit facilitated access and thus no intellectual property of any type can be claimed, or:
- that intellectual property can be taken out, provided it does not limit facilitated access (e.g. UPOV-compatible Plant Breeders' rights could be claimed).

There is also some lack of clarity as to whether the facilitated access that might be limited by the taking out of IPRs refers to limiting access to the original accession(s) (plus their genetic parts and components, however defined) or to the product of research and breeding using the material received.

Perhaps the greatest difficulty is the phrase "in the form received". Does this allow IPRs to be taken out, for example, on genes isolated from the material received, because they were not received in the form of isolated genes? Or is this forbidden because the gene itself (provided no changes are made to it) was received from the multilateral system, albeit embedded within the genetic makeup of the material?

Furthermore, the issue is left open as to what is the minimum that a recipient has to do for the material to no longer be classified as being "in the form received". Is the addition of a single 'cosmetic' gene (e.g. through transformation or conventional back-crossing) sufficient? Is inclusion of an essentially unaltered gene within a new construct sufficient? Such issues will presumably be addressed by the Governing Body in due course, and some, perhaps, by the Commission on Genetic Resources acting as Interim Committee.

Paragraph (g) specifies that materials accessed should continue to remain available to the multilateral system from the recipient (as long as the recipient has them).

Paragraph (h) confirms that access will also be provided to materials found in *in situ* conditions, although such access is to be provided according to national legislation. It is assumed that this national legislation deals with the mechanics of implementation (countries were concerned, for instance, with the modalities of access to materials in national parks and other protected or vulnerable areas) and not with the establishment of new requirements or conditions that are inconsistent with the Treaty. National legislation pertaining to *in situ* materials must allow for access if this provision is to be "without prejudice to the other provisions under this Article," as the paragraph states.

As with proprietary information, Article 12 provides some exceptions to what kinds of genetic materials must be made available, and when. Contracting Parties and centres need not make genetic material "under development" available during its period of development. While the intention of paragraph (e) may be reasonably clear, the wording of this provision is problematic in that it does not specify what "under development" means, nor does it define when the "period" of development ends.

Paragraph (f) specifies that materials protected by IPRs will be made available in a manner consistent with those rights.

None of the paragraphs makes specific reference to practical implementation points that may concern the centres such as whether there is an obligation to transfer diseased materials in contradiction of quarantine laws and regulations (presumably there is not).

12.4 To this effect, facilitated access, in accordance with Articles 12.2 and 12.3 above, shall be provided pursuant to a standard material transfer agreement (MTA), which shall be adopted by the Governing Body and contain the provisions of Articles 12.3(a), (d) and (g), as well as the benefit-sharing provisions set forth in Article 13.2(d)(ii) and other relevant provisions of this Treaty, and the provision that the recipient of the plant genetic resources for food and agriculture shall require that the conditions of the MTA shall apply to the transfer of plant genetic resources for food and agriculture to another person or entity, as well as to any subsequent transfers of those plant genetic resources for food and agriculture.

Paragraph 12.4 mandates the use of a standard Material Transfer Agreement—a system very similar to that used by CGIAR centres today. The MTA would bind the recipient of Annex I PGRFA to certain conditions and would require that recipient to pass on these obligations to any subsequent recipient. The Treaty does not specify the form of the MTA, whether it is to be signed or, like the MTA used by CGIAR centres, employ the "software" approach. Informally, CGIAR representatives have argued that signed MTAs (1) add to the bureaucracy of implementation, (2) provide no additional or significant legal advantages and that recourse to the courts is rarely the route taken in cases of infringement in any case, and (3) the procedures involved in obtaining signatures in many countries result in inhibiting flows of germplasm.

The main provisions of the MTA will deal with IPRs and with the benefit-sharing requirement, discussed above. The precise content of the MTA, and thus both the "formula" for benefit-sharing and the procedures for administering the MTAs, is not specified by the Treaty. These matters were left to the Governing Body to decide. Article 13 on Benefit-Sharing specifies that the "form and manner of payment" will be determined "in line with commercial practice" by the Governing Body at its first meeting, which will take place within a year of the Treaty's coming into force. It is important to point out that these decisions, like all decisions by the Governing Body, must be taken by consensus

(unless, by consensus, they decide on another method).

12.5 Contracting Parties shall ensure that an opportunity to seek recourse is available, consistent with applicable jurisdictional requirements, under their legal systems, in case of contractual disputes arising under such MTAs, recognizing that obligations arising under such MTAs rest exclusively with the parties to those MTAs.

12.6 In emergency disaster situations, the Contracting Parties agree to provide facilitated access to appropriate plant genetic resources for food and agriculture in the Multilateral System for the purpose of contributing to the re-establishment of agricultural systems, in cooperation with disaster relief co-ordinators.

Paragraph 12.5 simply states that Contracting Parties will ensure that there is some mechanism in their legal system for addressing violations of the MTA. (It should be noted that the Treaty does not specify the legal jurisdiction applicable to the MTA. Often contracts, such as MTAs, would do this, saying, for example, that in the case of a dispute, the relevant laws of a named country would apply.) Paragraph 12.5 is tied to Article 21 on compliance. Article 21 provides for legal assistance and advice to be made available, presumably by the Governing Body.

Paragraph 12.6 provides for the provision of materials needed to restore agricultural systems in disaster situations regardless of whether the recipients are Contracting Parties to the Treaty or not. This paragraph was drafted in support of the Global Plan of Action, which has an "Activity" devoted to this issue.

Benefit-sharing

The Treaty's article on Benefit-Sharing (Article 13) recognizes that access itself is a major benefit of the Multilateral System, and states that benefits arising from the use of PGRFA under the Multilateral System should be shared fairly and equitably through a number of mechanisms, both voluntary and mandatory in nature.

Contracting Parties agree, for example, to "provide and/or facilitate access to technologies for the conservation, characterization, evaluation and use of plant genetic resources." This particular paragraph [13.2.(b)(i)] encourages the transfer of technologies including those that are essentially "embedded" in genetic materials. But, the transfer is not mandatory, and respect for property rights is specifically accommodated.

Likewise, Article 13 encourages (but does not set forth enforceable requirements for) capacity-building in developing countries and countries with economies in transition. Elements identified in the article include training, strengthening of facilities and the carrying out of research in these countries.

13.2(a) The Contracting Parties agree to make available information which shall, *inter alia*, encompass catalogues and inventories, information on technologies, results of technical, scientific and socio-economic research, including characterization, evaluation and utilization, regarding those plant genetic resources for food and agriculture under the Multilateral System. Such information shall be made available, where non-confidential, subject to applicable law and in accordance with national capabilities. Such information shall be made available to all Contracting Parties to this Treaty through the information system, provided for in Article 17.

Confidential and proprietary information is not covered by this mandatory requirement. And, all transfers are contingent on and subject to any relevant intellectual property rights.

13.2(d)(ii) The Contracting Parties agree that the standard Material Transfer Agreement referred to in Article 12.4 shall include a requirement that a recipient who commercializes a product that is a plant genetic resource for food and agriculture and that incorporates material accessed from the Multilateral System, shall pay to the mechanism referred to in Article 19.3(f), an equitable share of the benefits arising from the commercialization of that product, except whenever such a product is available without restriction to others for further research and breeding, in which case the recipient who commercializes shall be encouraged to make such payment.

The Governing Body shall, at its first meeting, determine the level, form and manner of the payment, in line with commercial practice. The Governing Body may decide to establish different levels of payment for various categories of recipients who commercialize such products; it may also decide on the need to exempt from such payments small farmers in developing countries and in countries with economies in transition. The Governing Body may, from time to time, review the levels of payment with a view to achieving fair and equitable sharing of benefits, and it may also assess, within a period of five years from the entry into force of this Treaty, whether the mandatory payment requirement in the MTA shall apply also in cases where such commercialized products are available without restriction to others for further research and breeding.

Article 13.2(d)(ii) is arguably the most interesting and controversial provision related to benefit-sharing. This paragraph lays out a mandatory benefit-sharing scheme connected to the commercialization of PGRFA incorporating materials from the multilateral system. The previously mentioned MTA will contain the benefit-sharing requirement and will bind the recipient of germplasm from the system to provide monetary benefits in certain circumstances.

When a recipient receives material from the multilateral system and uses that material to produce a commercial product that "is a PGRFA," then the recipient will be obliged to pay "an equitable share of the benefits arising from the commercialization of that product." This requirement, it should be understood, will not apply to the commercialization of a product, such as bread containing wheat produced by a variety incorporating material obtained from the multilateral system. The requirement will, however, apply to the variety—to the *plant genetic resource*—that has been commercialized. The Governing Body, at its first meeting, is supposed to determine "the level, form and manner of the payment, in line with commercial practice." The payment will be made into a mechanism such as a trust fund established at FAO and controlled by the Governing Body. This fund would be used to support activities consistent with the goals of the Treaty, taking into consideration the Global Plan of Action. The benefits, according to the Treaty, should flow "primarily, directly and indirectly, to farmers…" At its first meeting the Governing Body (see Article 13.4) will "consider relevant policy and criteria for specific assistance under the agreed funding strategy."

There is one exception to the requirement to make a monetary payment, and it is a big exception. When the product—for example, the new crop variety—is made available "without restriction to others for further research and breeding," no payment is required, though it is encouraged. In practice, it would appear that this means that varieties incorporating material from the multilateral system that are protected by UPOV-styled Plant Breeders' Rights, will not be subject to mandatory, monetary benefit-sharing. Why?

Because, such varieties are freely available for further research and breeding. Varieties and other materials that are protected by utility patents will be subject to the benefit-sharing requirement, however, because most patent laws restrict the use of the patented invention for research as well as for use as a breeding material. Presumably, a patent holder could renounce certain rights afforded by a patent and thus escape the mandatory benefit-sharing provision. For example, one could patent a variety or line and then grant any and everyone a licence to use the material freely for research and breeding. So-called "protective patenting" would, in our view, not necessarily trigger Article 13's monetary benefit-sharing requirement, but this may need clarification by the Governing Body.

Opinions are divided, however, as to whether a breeder from a company or institution would or would not be obtaining materials from the multilateral system were he/she to get materials from his/her national genebank. One could argue that the Treaty regulates transfers between (not within) Parties, and that in some cases, internal transfers (e.g. between an institute's genebank and its breeders) would essentially be from one "legal person" to the same "legal person". At the least, access from the multilateral system involves an international transfer of materials, with the exception that access by a CGIAR centre from a genebank in the host country would, of course, be considered access from the multilateral system, assuming that country is a Contracting Party.

As the second paragraph of 13.2(d)(ii) notes, the Governing Body may elect to establish different levels of payments for different categories of users that commercialize products covered by this article. It will also review the level of payments from time to time. And, within five years of the Treaty coming into force, the Governing Body will specifically examine whether the system of mandatory payments should be extended to cover products that are available without restriction for further research and breeding. Given the fact that such a decision to expand the scope of the mandatory benefit-sharing scheme would have to be made by consensus, the likelihood of the Governing Body taking this step would appear slim at this point.

Finally, Contracting Parties have agreed (in Article 13.6) at some unspecified point in the future to consider "modalities of a strategy of voluntary benefit-sharing contributions" from food-processing industries. Again, it does not appear that this provision is going to lead to an expansion of mandatory benefit-sharing.

The scope of the Multilateral System

Overview

The Multilateral System covers PGRFA that are in the public domain and under the management and control of the Contracting Parties. Approximately 35 crops and a modest number of forage species are affected by the provisions of the Multilateral System. Soyabean, groundnut, sugarcane, tomato and most tropical forages are excluded from the system. Certain species that are part of the genepool used by breeders of cassava, potato and common beans are also excluded.

The multilateral system includes "all PGRFA listed in Annex I that are under the management and control of the Contracting Parties and in the public domain" (Article 11.2). Contracting Parties (countries) agree to encourage the private sector and other relevant organizations within their jurisdiction to include such materials in the multilateral system. In effect this means that the multilateral system contains materials under government control and in the public domain, in addition to such materials that others might voluntarily put under the system. Within two years of entry into force, the Governing Body will assess progress in getting such materials into the system.

As is well known, negotiators debated the content of Annex I extensively and vigorously. Early on, they agreed in principle that crops included in the multilateral system would be those important for food security and for which countries were interdependent. Such criteria, as valid as they might be, do not provide a formula for inclusion/ exclusion, and thus the selection of crops from beginning to end was highly politicized. Annex I lists some 35 crops (or in the case of *Brassicas*, crop complexes) and a number of forages.

In addition to the problem of which crops to include, negotiators faced the related problem of how to define each crop in operational terms such that one might know, rather precisely, what was and was not covered. There was never any doubt that wheat would be included in the multilateral system. But, what, precisely, does "wheat" really mean? IPGRI assisted in organizing panels of experts to provide scientific information on these and other questions (such as which forage species are most important to food security). The advice of the experts was not always heeded. In the end, negotiators defined crops, often as much on the basis of political as scientific criteria, by genus/ genera, noting whenever a particular genus or species was *excluded*.

In some cases, negotiators decided to exclude specific species associated with a crop, and in some cases the excluded species are ones typically considered part of the genepool that a breeder might use or want access to. Two examples would be *Phaseolus polyanthus* and *Solanum phureja*. The definition of cassava specifies *Manihot esculenta* only; thus wild relatives now being used to increase protein content and improve disease resistance are excluded. Finally, some definitions are simply ambiguous. For example, wheat is defined as "*Triticum* et al."

CGIAR centres will continue to distribute non-Annex I materials—probably under an MTA containing provisions identical or close to those found in the MTA that Contracting Parties and centres will be using for Annex I materials. Article 15 encourages Contracting Parties to provide centres with non-Annex I materials that are important to the programmes of the centres, but access will be at the discretion of the countries, who will set the terms of access, if they provide it at all.

Additionally, donors may question whether they wish to provide funding for work on crops that are not part of the multilateral system–crops for which countries have decided to handle conservation, development and benefit-sharing individually or through bilateral arrangements. Unless countries are willing to provide non-Annex I materials, some genebank collections risk becoming "fixed in time". Genebank managers and other officials may therefore wish to discuss this situation with relevant countries and try to come to some agreement that will ensure continued flow of materials for conservation and development purposes.

Additions (and exclusions) to Annex I can be made by the Governing Body—by consensus. In all likelihood, the list of crops is "fixed" for some time.

General provisions of the Treaty

The foregoing analysis has focused on the Treaty's establishment of a multilateral system for access and benefit-sharing. The Treaty, however, covers a number of general topics, and contains some 17 articles dealing with institutional matters such as the operations of the Governing Body, the Secretariat, etc. Below, we provide a very brief description of the remaining articles.

Preamble:

The Preamble notes the importance of PGRFA and recognizes the contributions farmers have made in conserving and making available these resources. It describes the Global Plan of Action as the internationally agreed framework for PGRFA-related activities. Significantly, the Preamble states that the Treaty

does not imply a change in the rights or obligations of Parties under other international agreements, and states that this is not meant to imply a hierarchy between this Treaty and other agreements. Finally, the Preamble notes that the Treaty will be within the framework of FAO, and operate under Article XIV of the FAO Constitution.

Article 1. Objectives:
The objectives are the conservation and sustainable use of PGRFA and the fair and equitable sharing of benefits arising out of their use. Article 1 notes that this is in harmony with the Convention on Biological Diversity (CBD).

Article 2. Use of Terms:
Eight terms are defined. Most of the definitions are based, at least loosely, on those found in the CBD. In the final days of the negotiations, there was considerable debate over the definitions. The need to compromise influenced the wording of two definitions in particular. The compromise-induced ambiguity may become the source of problems in the future in determining what exactly is covered by certain provisions of the Treaty. The two "problematic" definitions:

"Plant genetic resources for food and agriculture" means any genetic material of plant origin of actual or potential value for food and agriculture.

"Genetic material" means any material of plant origin, including reproductive and vegetative propagating material, containing functional units of heredity.

In the latter definition, it may be unclear as to which clauses modify or "define" others, and this in turn could lead to confusion as to which materials are, for example, affected by the article on facilitated access to PGRFA.

Finally, it should be noted that some important terms are *not* defined. This may also lead to confusion and controversy. The best example of this involves a term used in Article 12.3(d) which states that "Recipients shall not claim any intellectual property or other rights that limit the facilitated access to the plant genetic resources for food and agriculture, or their genetic parts or components, in the form received from the multilateral system." The term "genetic parts or components" is not defined, nor is the term "in the form received."

Article 3. Scope:
The Treaty relates to PGRFA. It is important to note that it covers more than just the crops in the multilateral system (which is dealt with in Part IV of the Treaty). Other articles, for example, on conservation and sustainable use, international cooperation, the Global Plan of Action, networks, the Global Information System and the funding strategy, are not limited to multilateral system crops.

Article 4. General Obligations:
Parties must ensure that their laws and regulations conform to the obligations laid out in the Treaty.

Article 5. Conservation, Exploration, Collection, Characterization, Evaluation and Documentation of PGRFA:
"Subject to national legislation", Contracting Parties agree to undertake the above activities and to cooperate with each other. No firm obligations are contained in the article; nevertheless, the article sends signals about the priorities of countries. For instance, it states that Contracting Parties will "cooperate to promote the development of an efficient and sustainable system of *ex situ* conservation."

Article 6. Sustainable Use of PGRFA:
Contracting Parties commit to developing appropriate policy and legal measures to promote the sustainable use of PGRFA. The article provides examples of what these measures *may* include: policies promoting diverse farming systems ("as appropriate"), strengthening of research, base broadening, expanded use of local crops and varieties

("as appropriate"), reviewing breeding strategies and regulations regarding variety release and seed distribution, etc. As with many other articles, this article contains no specific "enforceable" obligations. However, for those who wish to use the contents as guidance or to encourage governments to undertake activities (e.g. base broadening) the encouragement and guidance are here.

Article 7. National Commitments and International Cooperation:
Contracting Parties commit to integrating the activities referred to in Articles 5 and 6 into their agricultural and rural development programmes. International cooperation shall be directed in particular to capacity-building in developing countries and countries with economies in transition, enhancing international activities, strengthening institutional arrangements and implementing the Treaty's funding strategy.

Article 8. Technical Assistance:
Parties agree to "promote the provision of technical assistance".

Article 9. Farmers' Rights:
Over time, "Farmers' Rights" has come to mean different things to different people. To some it is associated with a desire for a form of intellectual property rights for farmer-developed materials; to others it is a political slogan that leads to recognition of farmers' contributions and more PGRFA-related activities of benefit to small, traditional farmers. Article 9, at least, "settles" the issue as regards the "international" implications of the term. In Article 9, Contracting Parties recognize the contribution of farmers, but state that the responsibility for the realization of Farmers' Rights rests with national governments. Each Contracting Party, "in accordance with their needs and priorities…as appropriate, and subject to national legislation", agrees to take measures to protect and promote Farmers' Rights, including the protection of traditional knowledge, the right to participate in benefit-sharing, and the right to participate in making decisions at the national level regarding PGRFA. As with other articles described above, the obligations are too vague and too conditioned by phrases such as "as appropriate" to amount to a firm commitment to do anything specific. Article 9.3 notes that "Nothing in this Article shall be interpreted to limit any rights that farmers have to save, use, exchange and sell farm-saved seed/propagating material, subject to national law and as appropriate." In other words, if they have rights, they have them; if they don't, they don't.

Article 14. Global Plan of Action:
Contracting Parties agree to promote the effective implementation of the GPA as an international framework for PGRFA-related efforts, taking into account Article 13 on Benefit-Sharing.

Article 15.* Ex Situ *Collections of Plant Genetic Resources for Food and Agriculture held by the International Agricultural Research Centres of the Consultative Group on International Agricultural Research and other International Institutions:
In 1994, CGIAR centres concluded agreements with FAO, placing collections of germplasm "in trust" for the benefit of the international community, under the auspices of FAO. It was understood that these agreements were interim, pending completion of the intergovernmental negotiations on the Treaty.

The Treaty will become binding for CGIAR centres, when they (individually) sign agreements with the Governing Body of the Treaty—assuming centres choose to do so. As there will be no "Governing Body" until the treaty itself is ratified by a minimum of 40 countries, the agreements with the Governing Body must await the Treaty's entry into force, and, until then, the current agreements with FAO, in the context of the International Undertaking, apply.

As noted earlier, the access and benefit-sharing provisions of the treaty will apply to Annex I materials held by CGIAR centres. Non-Annex I materials will continue to be available as well, though the current MTA used in their transfer will likely be amended in consultation with the Governing Body of the Treaty to reflect relevant provisions of the Treaty (e.g. those concerning benefit-sharing).

Non-Annex I material received and conserved after the coming into force of the Treaty would be available on terms mutually agreed with the country of origin or other country that acquired them in accordance with the CBD or other applicable law. Other provisions of the Treaty related to the centres are similar to those now in effect under the FAO-CGIAR Agreements.

Article 16. International Plant Genetic Resources Networks:
The Treaty calls for existing networks to be strengthened and new networks to be developed to achieve complete coverage of PGRFA. Contracting Parties agree to encourage participation by all relevant institutions—government, private sector, NGO, research and breeding, etc.

Article 17. The Global Information System on PGRFA:
Contracting Parties agree to cooperate to develop and strengthen a global information system, based on existing systems. Contracting Parties are encouraged to provide information that would allow "early warnings" of hazards to PGRFA to be issued with a view to safeguarding the material. Finally, Contracting Parties agree to cooperate with the FAO Commission in making periodic reassessments of the state of the world's PGRFA and to update the Global Plan of Action.

Article 18. Financial Resources:
Contracting Parties agree to "undertake to implement a funding strategy for the implementation of this Treaty." The Governing Body will periodically establish a target for such funding. Contracting Parties will take steps in other international mechanisms, funds and bodies to ensure that "due priority and attention to the effective allocation of predictable and agreed resources" is given to the implementation of plans and programmes under the Treaty. Contracting Parties agree to accord due priority to PGRFA in their own plans and priorities. Voluntary contributions to the Treaty's funding strategy are encouraged, and the Governing Body shall consider modalities of a strategy to encourage such contributions. Priority for funding will be given to "agreed plans and programmes for farmers" in developing countries (especially in least developed countries) and in countries with economies in transition.

Article 19. Governing Body:
The Governing Body consists of the Contracting Parties, i.e. those countries that have formally ratified the Treaty. (Countries that voted to adopt the Treaty at the FAO Conference in November 2001, or subsequently sign the Treaty, are *not* members of the Governing Body unless they also take the step of formally ratifying it. Ratification is the key.) The Governing Body provides policy direction and guidance, adopts plans, programmes and budgets, is empowered to establish subsidiary bodies (e.g. committees), etc. It will adopt a funding strategy at its first session, and will periodically set a target for this strategy, "taking the Global Plan of Action" into account. The Governing Body may also consider and adopt amendments to the Treaty. Article 19 states that the Governing Body will keep the Conference of the Parties to the CBD informed of its work.

The most controversial element in Article 19 concerns how decisions will be taken. According to the Article, "All decisions of the Governing Body shall be taken by consensus" unless, by consensus, another method is agreed. It remains to be seen whether this

"one-country one-veto" approach will allow the Treaty to evolve, or even to resolve the contentious issues that are already on its agenda, such as the terms of benefit-sharing to be embodied in the standard Material Transfer Agreement. Similarly, enlargement of the list of crops in the multilateral system would seem unlikely in the near future given that unanimous approval would be needed for adding any crop.

The Governing Body shall meet every two years, back-to-back with meetings of the FAO Commission on Genetic Resources, if possible. Other meetings may be called, as necessary.

Article 20. Secretary:
The Secretary shall be appointed by the Director-General of FAO. The Secretariat shall provide practical and administrative support for the Governing Body.

Article 21. Compliance:
At its first session, the Governing Body shall consider and approve "cooperative and effective" operational mechanisms to promote compliance and to address issues of non-compliance. Examples of this (cited specifically in the article) might be monitoring and provision of advice and assistance, including legal advice and assistance. Note that this Article's provisions, presumably, would indicate that the Governing Body, through the Secretariat might have some responsibilities for, or at least may assist with, promoting and ensuring MTA compliance.

Article 22. Settlement of Disputes:
In the event of disputes between Contracting Parties, Contracting Parties shall seek solutions through negotiation. A third party might be recruited to mediate. Arbitration procedures are laid down in Annex II to the Treaty, and are typical for treaties. Submission of the dispute to the International Court of Justice is an option. Conciliation in accordance with Annex II is another, final, option.

Article 23. Amendments to the Treaty:
Amendments may be proposed by any Contracting Party. All amendments will be made by consensus, and shall come into force 90 days after approval.

Article 24. Annexes:
Annexes are an integral (binding) part of the Treaty. Amendments to Annexes shall be by consensus.

Article 25. Signature:
The Treaty is open for signature (a tangible expression of support and intention to ratify) for one year. (The Treaty may, of course, be ratified by any country regardless of whether it has signed the Treaty within that year.)

Article 26. Ratification, Acceptance or Approval:
Instruments of ratification shall be deposited at FAO.

Article 27. Accession:
The Treaty is open for "accession", a legal term for ratification or approval that applies to countries that have not signed the Treaty in the year in which it is open for signature (see Article 25). Countries that exercise this option enjoy equal rights and status with those that sign and ratify–no distinction is made.

Article 28. Entry into Force:
The Treaty shall enter into force 90 days after the 40th instrument of ratification or accession is deposited with FAO. Following this, the Treaty comes into effect for subsequent countries, 90 days after they ratify/approve the Treaty.

Article 29. Member Organizations of FAO:
This Article pertains to entities such as the European Community, and how it notifies the Body of its competence to speak for the group, or not, in meetings. Ratification by the EU is not counted in addition to its

member states when determining whether 40 countries have ratified the Treaty.

Article 30. Reservations:
No reservations may be made to the Treaty by Contracting Parties.

Article 31. Non-Parties:
The Contracting Parties agree to encourage non-Parties to accept the Treaty. This is the only mention of non-Parties in the Treaty. There was much discussion earlier of whether the Treaty would dictate the use of different (potentially discriminatory) treatment of non-Parties (in terms of access and benefit-sharing, for instance). In the end, the Treaty is silent on the issue. Presumably, this means that the Treaty does not govern or affect the dealings of Contracting Parties or CGIAR centres with non-Parties.

Article 32. Withdrawals:
At any time after two years after the coming into force of the Treaty, Parties may withdraw by formally notifying FAO. Withdrawal takes effect one year after the receipt of such notification.

Article 33. Termination:
If the number of Contracting Parties drops below 40, the Treaty will be automatically terminated.

Article 34. Depositary:
The Director-General of FAO shall be the Depositary of the Treaty.

Article 35. Authentic Texts:
The official texts of the Treaty are in Arabic, Chinese, English, French, Russian and Spanish. Each is equally authentic.

Issues and concerns

Overview
As with most treaties, this Treaty contains ambiguities and instances where important text is open to conflicting interpretations. Major problems or challenges have been bequeathed to the Treaty's future Governing Body, which will attempt to resolve remaining issues *by consensus*. Until they do, ambiguities will remain, and Contracting Parties will implement the Treaty in light of their understanding of it. Lack of clarity will pose difficulties for Contracting Parties and CGIAR centres, equally.

Overview
Treaties are developed largely through political, not scientific, processes. This would seem so obvious as not to warrant comment. Nevertheless, with treaties addressing largely scientific topics, questions are inevitably raised about the quality of "science" found in the document: Don't they understand that…? Why didn't they…? Didn't our representatives explain that…? Look, these two paragraphs are contradictory! Why are the definitions of scientific terms so "political"?

The International Treaty on Plant Genetic Resources for Food and Agriculture is the result of a long–and most would say, gruelling–series of political negotiations between countries. The first proposals for a legally binding Treaty on the subject were made in 1981. The current round of negotiations commenced in 1994. The subject of the Treaty was, and remains, controversial, and the Treaty itself is the result of countless compromises. From anyone's vantage point, it is less than perfect. "Perfection", however, was never one of the options on the table. From any perspective, the Treaty contains ambiguities and unresolved problems, some of which were known and visible to negotiators, some of which were probably not. Certain problems exist simply because negotiators could not agree on a solution and decided instead to move forward, accepting

the fact that ambiguities exist and that future disputes will arise.

What follows is an exploration of some of these ambiguities and "problems".

Definitional issues

There is lack of clarity about the precise meaning of certain terms used in the Treaty. This lack of clarity exists even in Article 2, where terms are defined. Uncertainties over the meaning of terms in the text will, of course, affect both countries and CGIAR centres.

The most troubling ambiguities are those pertaining to what—precisely—is being accessed under the multilateral system, how it can be used/protected, and under what conditions access might be denied or conditioned. Article 12.3(d), for instance, states: "Recipients shall not claim any intellectual property or other rights that limit the facilitated access to the plant genetic resources for food and agriculture, or their genetic parts or components, in the form received from the multilateral system." The term "genetic parts and components" is not defined and would be subject to different interpretations. More problematic is the term "in the form received." Some countries were of the opinion that this paragraph would preclude the kind of patenting of genes which is allowed in the United States, namely the patenting of an isolated, purified DNA molecule for which a function (utility) is identified. These countries claim that the patented gene is the same as that received. Others counter that the isolated and purified form is different from the "form received" from the multilateral system.

Once it is determined that materials from the multilateral system have been used in such a way as to trigger the mandatory benefit-sharing mechanism of the Treaty, Article 13.2(d)(ii) says that the level, form and manner of the payment will be "in line with commercial practice." What "commercial practice" is remains to be defined. At this point, it is not clear whether Contracting Parties will try to define this in operational terms in the text of the yet-to-be-drafted Material Transfer Agreement, or whether they will decide to formulate guidelines, for instance. Unless precise royalty percentages are identified in the MTA, it is also not clear who will be authorized to make the final determination of an amount of payment due under 13.2(d)(ii). Of course, some accessions will contribute more, quantitatively or qualitatively, to a final product, and thus one could envisage a system that would differentiate according to use. Such a system might require multiple royalty rates. These issues are likely to be addressed by negotiation within the Interim Committee and the Governing Body.

Finally, in terms of definitional issues, we note Article 12.3(e) on access. This paragraph states that "Access to plant genetic resources for food and agriculture under development, including material being developed by farmers, shall be at the discretion of its developer, during the period of its development." What does "during the period of its development" mean? When does this period begin and end? What actions constitute "development"? Presumably, certain normal practices would be allowed, for example the development and retention (without mandatory access being made available) of multiple lines for use in producing a variety; for the development of materials that would be made available under contract or sold to another entity, etc.

The list of crops for the Multilateral System

Annex I was the subject of passionate debate and substantial scientific input from experts (e.g. the results of technical workshops, the reports of groups of experts, etc.). Nevertheless, the text is less than clear in certain regards. "Wheat" is included in Annex I, but defined as "*Triticum* et al." Et al.? In addition, the Treaty does not acknowledge the fact that taxonomists and breeders will disagree about what is included within a particular genus or even species. Moreover, such groupings

change over time. Will the materials under the multilateral system expand and contract as taxonomic understandings of what constitutes a particular genus evolve? Assuming that the Governing Body will not want to undertake the cumbersome and costly task of constituting its own taxonomic authority, on what basis will Contracting Parties and CGIAR centres decide whether questionable categories/materials are included or excluded? Practically speaking, how would the Treaty handle cases if materials considered today to be part of Annex I were to fall off the list by virtue of changes in taxonomic practices?

Non-Parties

The Treaty regulates relations between Contracting Parties, and between centres (that agree to be bound by provisions of the Treaty) and Contracting Parties. Like most treaties, it does not specify relations with non-Parties. The Treaty's article on non-Parties (Article 31), as noted above, simply states that non-Parties are encouraged to accept the Treaty. The FAO Commission, through its agreement with CGIAR centres, has already confirmed the history of CGIAR-held accessions, i.e. that they were "donated or collected on the understanding that these accessions will remain freely available and that they will be conserved and used in research on behalf of the international community, in particular the developing countries." Given this understanding, we cannot logically interpret the Treaty as implying that access to non-Parties would be denied. It would be equally illogical, however, to argue that access to non-Parties would be without any terms or conditions. We may assume, therefore, that access to non-Parties—to all in the international community—should be provided by centres, assuming that the non-Party accepts the terms and conditions in the new MTA. Countries will be clearly have more discretion to decide whether to provide access to non-Parties, and if so, on what terms. The Treaty does not mandate a particular course of action in this regard.

Annex I. List of crops covered under the multilateral system

FOOD CROPS **Crop**	**Genus**	**Observations**
Breadfruit	*Artocarpus*	Breadfruit only
Asparagus	*Asparagus*	
Oat	*Avena*	
Beet	*Beta*	
Brassica complex	*Brassica* et al.	Genera included are: *Brassica, Armoracia, Barbarea, Camelina, Crambe, Diplotaxis, Eruca, Isatis, Lepidium, Raphanobrassica, Raphanus, Rorippa*, and *Sinapis*. This comprises oilseed and vegetable crops such as cabbage, rapeseed, mustard, cress, rocket, radish and turnip. The species *Lepidium meyenii* (maca) is excluded
Pigeon Pea	*Cajanus*	
Chickpea	*Cicer*	
Citrus	*Citrus*	Genera *Poncirus* and *Fortunella* are included as root stock

Annex I. (cont.)

Crop	Genus	Observations
Coconut	*Cocos*	
Major aroids	*Colocasia, Xanthosoma*	Major aroids include taro, cocoyam, dasheen and tannia
Carrot	*Daucus*	
Yams	*Dioscorea*	
Finger millet	*Eleusine*	
Strawberry	*Fragaria*	
Sunflower	*Helianthus*	
Barley	*Hordeum*	
Sweet potato	*Ipomoea*	
Grass pea	*Lathyrus*	
Lentil	*Lens*	
Apple	*Malus*	
Cassava	*Manihot*	*Manihot esculenta* only
Banana / Plantain	*Musa*	Except *Musa textilis*
Rice	*Oryza*	
Pearl millet	*Pennisetum*	
Beans	*Phaseolus*	Except *Phaseolus polyanthus*
Pea	*Pisum*	
Rye	*Secale*	
Potato	*Solanum*	Section tuberosa included, except *Solanum phureja*.
Eggplant	*Solanum*	Section melongena included
Sorghum	*Sorghum*	
Triticale	*Triticosecale*	
Wheat	*Triticum et al.*	Including *Agropyron*, *Elymus* and *Secale*
Faba bean / Vetch	*Vicia*	
Cowpea *et al.*	*Vigna*	
Maize	*Zea*	Excluding *Zea perennis*, *Zea diploperennis* and *Zea luxurians*

FORAGES

Genus	Species
Legumes	
Astragalus	*chinensis, cicer, arenarius*
Canavalia	*ensiformis*
Coronilla	*varia*
Hedysarum	*coronarium*
Lathyrus	*cicera, ciliolatus, hirsutus, ochrus, odoratus, sativus*

Annex I. (cont.)

FORAGES	
Genus	**Species**
Lespedeza	*cuneata, striata, stipulacea*
Lotus	*corniculatus, subbiflorus, uliginosus*
Lupinus	*albus, angustifolius, luteus*
Medicago	*arborea, falcata, sativa, scutellata, rigidula, truncatula*
Melilotus	*albus, officinalis*
Onobrychis	*viciifolia*
Ornithopus	*sativus*
Prosopis	*affinis, alba, chilensis, nigra, pallida*
Pueraria	*phaseoloides*
Trifolium	*alexandrinum, alpestre, ambiguum, angustifolium, arvense, agrocicerum, hybridum, incarnatum, pratense, repens, resupinatum, rueppellianum, semipilosum, subterraneum, vesiculosum*
Grasses	
Andropogon	*gayanus*
Agropyron	*cristatum, desertorum*
Agrostis	*stolonifera, tenuis*
Alopecurus	*pratensis*
Arrhenatherum	*elatius*
Dactylis	*glomerata*
Festuca	*arundinacea, gigantea, heterophylla, ovina, pratensis, rubra*
Lolium	*hybridum, multiflorum, perenne, rigidum, temulentum*
Phalaris	*aquatica, arundinacea*
Phleum	*pratense*
Poa	*alpina, annua, pratensis*
Tripsacum	*laxum*
Other forages	
Atriplex	*halimus, nummularia*
Salsola	*vermiculata*

V. The Convention on Biological Diversity

Relevance to genetic resource professionals

The Convention on Biological Diversity (CBD) is an ambitious attempt to integrate previously distinct policy goals. It entered into force in 1993 and as of 15 March 2001, had 183 Parties. It recognizes the pervasive importance and distribution of biodiversity and requires protection of all biodiversity in all types of ecosystems and habitats. The CBD applies to all types of genetic resources (microbial, plant, animal, aquatic and marine), both wild and domesticated. Nevertheless, the impetus for the treaty was from an environmental constituency and the negotiators by and large came from national Ministries of Environment with little or no focus on the PGRFA. At the conclusion of the treaty the negotiators passed a resolution, Resolution 3 of the Nairobi Conference of 22 May 1992, calling for certain outstanding issues related to PGRFA to be addressed within the FAO Global System.

One of the outstanding issues was the status of genetic resources held in *ex situ* collections prior to the Convention's entry into force. As will be discussed in detail in section II below, the CBD establishes international legal principles for access to genetic resources held in both *in situ* and *ex situ* conditions. The CBD, however, only applies to genetic resources held in *ex situ* conditions that were acquired after its entry into force and therefore does not cover pre-CBD collections. And, as noted in Chapter 4 it no longer effectively applies to post-entry into force of collections of IT Annex I crops. The other outstanding issue identified in Resolution 3 is the realization of Farmers' Rights. The revision of the International Undertaking was in part an effort to address these outstanding issues. The International Treaty clarifies how access and benefit-sharing to Annex I crops will be handled and thus the crops listed in Annex I represent the large majority of *ex situ* accessions. The IT does not, however, explicitly address the status of *ex situ* collections acquired prior to the CBD's entry into force that are not part of Annex I. The solution to how to address Farmers' Rights in the IT was to leave their implementation to the national level.

The IT and national law implementing it will now be the main entry point for a PGRFA manager concerned about legal requirements stemming from international obligations. Nevertheless, PGRFA not on the list will still fall under the Access and Benefit-Sharing (ABS) provisions of the CBD and it is therefore important for a GR professional to be aware of its requirements and orientation. National policy-makers should also be aware that the IT list can be amended and hence grow so it may be wise to retain flexibility in national ABS laws to accommodate these future changes.

Because the ABS provisions are the most relevant to the work of a GR professional, this chapter will begin by focusing on those requirements and how they have been implemented over the last several years. With the conclusion of the IT, in the CBD it is most important for the GR professional to understand its ABS principles and requirements and the relevant national implementation legislation. Nevertheless, because they may have relevance after discussing ABS, the chapter will briefly discuss other articles of relevance and some of the recent activities undertaken by the Parties for implementation of them.

Article 15: Access to genetic resources (and related provisions)

Relevant provisions

When dealing with access or distribution of genetic resources, the GR professional must first determine what, if any, international legal instrument and corresponding national law applies. If the resources in question are part of the IT list of multilateral system (Annex I) crops and the materials are under the management and control of a Contracting Party to that Treaty, then the provisions of the

IT apply (the list of crops can also be amended by consensus of the Parties after the IT enters into force). The access provisions of the CBD therefore apply to non-list PGRFA collected after the entry into force of the Convention. In addition, GR professionals will need to be aware of any crop or other networks that the country may have joined and any access and exchange regulations established by the network agreement, and whether these agreements are consistent with the IT. (Note: The IT establishes certain rules governing access and benefit-sharing for non-IT Annex I materials held by CGIAR centres. See Chapter 4.)

The CBD as a whole emphasizes national action and its provisions on access follow this orientation. A GR professional must therefore be aware of how his/her government has implemented the CBD provisions. An understanding of the general principles and orientation of the CBD on ABS may be helpful not only in understanding national laws that are created to implement, or at least are inspired by, the CBD but also in understanding some of the sensitivities that may underlie access and distribution of genetic resources.

Underpinning the Convention and at the heart of some of the most contentious debates among parties is the recognition of the States' sovereign rights over the genetic resources residing in their jurisdictions (Article 3). Article 15 recognizes as a corollary the sovereign rights of States over their natural resources, the authority of national governments to determine access to genetic resources, subject to national legislation.[2] Notwithstanding this recognition, each Contracting Party "shall endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions that run counter to the objectives of this Convention" (Article 15.2).

According to Article 15 paras 4 and 5 of the Convention, access, where granted, shall be on mutually agreed terms and subject to prior informed consent (PIC) of the Contracting Party providing genetic resources,[3] unless otherwise determined by that Party. While the general principles on access emphasize national action, they do not mandate bilateral transactions nor do they preclude parties from establishing or entering into regional or crop networks or a larger multilateral system of regulating access. Hence, governments, exercising their national sovereignty to do so and under the auspices of the FAO Commission, established a multilateral system in the IT and the Parties to the CBD repeatedly noted its support for this process.

Nevertheless, the fact remains that the requirements of mutually agreed terms and prior informed consent imply a bilateral transaction between a user and a provider of genetic resources. Insofar as the terms are not legislatively predetermined, in reaching mutually agreed terms for access a GR professional may wish to consider the administrative costs of implementing agreements whose terms vary from the norms of the genebank (for genebank managers) or the IT's Multilateral System. They may also want to ensure that the terms do not conflict with their mission as a GR professional, for example, ensuring the terms do not unduly restrict subsequent distribution to their constituents, or, in fact, to non-nationals in ways that will prompt them to deny access to materials that the genebank might need in the future. Many governments have passed or are considering ABS legislation. Before turning to the implementation trends, there are several other provisions on or related to access worth noting.

Paragraphs 6 and 7 of Article 15 also provide that each Contracting Party shall endeavour to develop and carry out scientific research based on genetic resources provided by other Contracting Parties with the full participation of, and where possible in, such Contracting Parties. Most importantly, each Contracting Party is bound to take legislative, administrative or policy measures with the aim of *sharing in a fair and equitable way the results of research and development and the*

benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources. Such sharing shall be upon mutually agreed terms (Article 1 paras. 6 and 7).

Article 8(j) of the CBD requires that Parties "shall, as far as possible and as appropriate" and "subject to [their] national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity, and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of benefits arising from the utilization of such knowledge, innovations and practices." Article 10 also contains provisions related to indigenous and local communities. Article 10(c) requires Parties to protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements, and (d) to support local populations to develop and implement remedial action in degraded areas where biological diversity has been reduced. Regulating access is one mechanism through which these provisions can be implemented. Some countries that have developed access legislation have, for example, provided for the PIC of relevant indigenous and local communities in order for an access permit to be granted. Genetic resources professionals must be careful in collecting and using resources associated with indigenous and local communities. First, GR professionals must familiarize themselves with regional or national policies, laws or regulations applicable in their country on the collecting, use and/or management of the genetic resources associated with indigenous and local communities and/or related knowledge, innovations and practices. Even in the absence of national regulations, GR professionals should proceed carefully by providing full, relevant information to indigenous and local communities involved or affected and by taking the appropriate steps to see that permission is obtained prior to initiating any activity.

Implementation issues of note

Multilateral implementation

At its fifth meeting in May 2000, the Conference of the Parties (COP) established the Ad Hoc Working Group on Access and Benefit Sharing. In October 2001, the Working Group created the draft "Bonn Guidelines" for state parties developing national legislation to regulate access to genetic resources and benefit-sharing. The Bonn Guidelines were adopted by the COPVI in April 2002. Though they are not binding, they still have a great deal of potential to influence how countries develop their access laws. Of relevance to indigenous and local communities, the Bonn Guidelines recommend that "the prior informed consent of indigenous and local communities… should be obtained, in accordance with their traditional practices, national access policies and subject to domestic laws" when parties seek access to their genetic resources and associated knowledge.[4] This is significant because the CBD does not explicitly state that it is necessary to get the PIC of constituent communities.

At its sixth meeting, in discussing access to genetic resources, the COP agreed to encourage disclosure of the country of origin and of traditional knowledge in IPR applications. There was long discussion on whether or not the scope of Guidelines would include derivatives and products. Ultimately, the COP agreed to include them in the indicative list of mutually agreed terms (MATs) and to remove them from the provision on scope, adding a reference to benefits arising from the commercial and other utilization of genetic resources. The COP decided to reconvene the Working Group on ABS to work on use of terms, other approaches, measures to support compliance with prior informed

consent (PIC) and MATs, and capacity-building needs. The Bonn Guidelines were adopted and contain sections on:

(1) *general provisions*, including key features, use of terms, scope, relationship with relevant international regimes and objectives;
(2) *roles and responsibilities in ABS*, including: Contracting Parties that are countries of origin of genetic resources, or other Parties that acquired resources in accordance with the Convention; users, in the implementation of MATs; providers; Contracting Parties having users in their jurisdiction and measures to support compliance with PIC and MATs; national focal points; and national competent authorities;
(3) *participation of stakeholders*;
(4) *steps in the ABS process*, including: an overall strategy; identification of steps; PIC, containing competent authorities, timing and deadlines, specification of use, procedures for obtaining PIC and process; MATs, containing basic requirements and an indicative list of typical MATs; and benefit-sharing, mentioning types, timing and distribution of benefits and mechanisms for benefit-sharing; and
(5) *other provisions*, including incentives, accountability in implementing ABS arrangements, national monitoring and reporting, means for verification, dispute settlement and remedies.

Appendix I of the Guidelines suggests elements for material transfer agreements, while Appendix II outlines monetary and non-monetary benefits.

With regard to intellectual property rights and access, in the same decision adopting the Guidelines, the COP also invited: Governments to encourage disclosure of the country of origin of genetic resources or traditional knowledge in IPR applications, where the subject matter of the application concerns or makes use of either of them in its development. The COP also requested information-gathering and analysis on the role of customary laws and practices, and the feasibility of an internationally recognized certificate of origin as evidence of PIC and MAT. It also requested Parties to send the CBD Secretariat information on national mechanisms for obtaining PIC of indigenous and local communities. To help Parties in understanding their IPR options in ABS arrangements, the COP invited WIPO to prepare a technical study on methods for requiring disclosure of genetic resources, the country of origin, traditional knowledge and its source, and evidence of PIC.

The Guideline objectives include contributing to poverty alleviation and supporting human food security. This will be important if countries use the guidelines as part of the process of developing a consistent ABS strategy. The Guidelines include language in relationship to other instruments saying that the guidelines' applications should be supportive of relevant international agreements and without prejudice to ABS provisions of the IU (now IT).

Capacity-building for ABS also received a lot of attention and draft elements were agreed upon. The Working Group also called upon the Secretariat to convene an open-ended intersessional working group to finalize these elements. The meeting was held in December 2002 and a draft capacity building action plan was adopted for consideration by the next meeting of the Conference of the Parties in 2004. Many of the capacity-building components relate to legal and policies measures and may provide a good opportunity for countries and institutions to build the skills necessary to develop ABS strategies that link the obligations and objectives stemming from the IT and the CBD.

The World Summit on Sustainable Development held in Johannesburg in the fall 2002 called for the development of an international regime on benefit-sharing arising out of the utilization of genetic resources. Part of the impetus for this initiative was the emphasis in the Bonn Guidelines for "user" provisions

in ABS regimes emphasizing the interactive nature of ABS and the need for mutual reinforcement. In PGRFA access is more accurately characterized as "exchange" given the independence of all countries and that all are both potentially sources and users of PGRFA. The Open-ended Ad Hoc Working Group on Access and Benefit Sharing of the CBD met in March 2003. The Working Group considered the WSSD recommendation to be for an international regime on access and benefit-sharing. While there is polarization on the need for and desirability of a regime, and its legal nature, it seems clear that this issue will be front and center in CBD discussions, at least in the near-term.

The Conference of the Parties has also requested all Parties to identify a national focal point for ABS. The list of focal points is carried on the CBD web page and is available in hard copy from the Secretariat. It will be important for these focal points and others in the position of making ABS policy and decisions to understand the differences between PGRFA and other biodiversity.

National implementation

The provisions of the CBD relating to access have been implemented at the national level through three different types of regulations:[5]

- Environmental laws: they generally charge a competent national authority to examine the issue and provide specific guidelines or regulations in the future. These laws are only "enabling" in nature (e.g. the laws adopted in Australia and some African countries[6]);
- Sustainable development, nature conservation, national parks, sectoral and biodiversity laws: this kind of law generally contain access provisions more detailed than the laws of the first type.[7] Most of these laws establish the principles of mutually agreed terms and prior informed consent for access, in some cases in great detail (e.g. Biodiversity Law of Costa Rica, Law No. 7788 of 1998);
- Access regulations: they specifically aim at establishing conditions on access for genetic resources. Few regulations in force fall within this category; e.g., the Philippines Executive Order 247 (1995), Decision 391 of the Andean Group (1996), including the implementing regulations issued in some of the Andean countries, and Brazilian Provisional Measure No. 2.126 (26 April 2001).

A common feature of access regulations is their broad scope: they apply to genetic resources in all sectors of biodiversity, whether maintained in *in situ* or *ex situ* conditions. Such regulations and those dealing more generally with genetic resources, such as the Biodiversity Law of Costa Rica, normally reaffirm the principle of national sovereignty, establish prior informed consent procedures and specify the conditions for the granting of permits. Among such provisions the following obligations are generally established on the party having access:

- full information about new products and/or knowledge developed from accessed materials
- priority access by the providing country to such new products and/or knowledge
- a share in financial and other benefits derived from the commercial exploitation of accessed materials
- obligatory deposit of a specimen of each accession
- transfer to third parties only after authorization
- involvement of local scientists in collecting/research.

Though there is little evidence about the implications of the access regulations enacted so far on the access to and research on genetic resources, concerns have arisen about their possible negative impact on collecting and research activities, including by the CGIAR International Centres. In the case of the Philippines, for instance, the local research community has strongly criticized the access regime as "too tedious, too costly,

too time consuming, and too broad, encompassing activities that do not have commercial prospects and thus frustrating efforts to better understand and conserve the country's biodiversity"[8].

The implementation of the Andean Group regulations has also raised serious concerns. No distinction is made according to the type of biodiversity involved, the genetic resources held *in situ* and in *ex situ* conditions are subject to the same substantive provisions, compliance with the regulation is burdensome, particularly for small companies and for research institutions, and the regulations retroactively apply to any collected materials.[9]

Article 9: *Ex situ* conservation

In Article 9 the Treaty addresses the issue of *ex situ* conservation "predominantly for the purpose of complementing *in situ* measures", requiring that *ex situ* conservation be preferably undertaken in the country of origin of the genetic resources, including measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions.

In terms of collecting, paragraph (d) requires Parties to regulate and manage the collecting of resources from natural habitats for *ex situ* conservation purposes so as to not threaten "ecosystems and *in situ* populations of species". GR professionals should note that guidelines have been prepared for the collecting of plants and animals at both the international level and within professional societies. One example is the FAO Code of Conduct for Plant Germplasm Collection and Transfer.

There are many initiatives currently underway to explore access regimes. The Like-Minded Group of Megadiverse countries has declared the development of effective ABS regimes to be a priority and is working with UNEP/GEF and IPGRI to develop a proposal for case studies. IPGRI has also launched a project doing research and holding workshops at the subregional level with the ultimate goal of developing a flowchart of decision-making points in ABS decisions and the information needed to access options at each point. The United Nations University is actively involved in ABS case studies in the Pacific region; the Foundation for International Environment Law and Development and SPDA (*Sociedad Peruana de Derecho Ambiental*) is involved in assessing the impact of the Andean Pact regime on actual access decisions and the flow of benefits. A more complete list of initiatives can be found on the CBD website (www.biodiv.org).

Agrobiodiversity

Multilateral implementation

The COP has repeatedly noted the importance and distinct characteristics of agrobiodiversity. Consequently, its decisions[10] have supported the revision of the IU to bring it into harmony with the CBD and have led to the establishment of a programme of work specifically addressing agrobiodiversity. The overall aim of the programme of work is to promote the objectives of the Convention in the area of agricultural biodiversity. The programme of work aims to:

- support the development of national strategies concerning agrobiodiversity and to promote their integration in sectoral and cross-sectoral plans and policies
- build upon existing plans of actions that have been agreed by countries such as the GPA
- ensure harmony with other relevant programmes of work under the CBD
- to promote synergy and coordination amongst relevant programmes of other international organizations.

The programme of work has four main elements. The first is an assessment operational objective which aims to provide a comprehensive analysis of the status and trends of the world's agrobiodiversity and of their underlying causes, as well as local knowledge and its management. The second is to "identify management practices, technologies and

policies that promote the positive and mitigate the negative impacts of agriculture on biodiversity, and enhance productivity and capacity to sustain livelihoods by expanding knowledge, understanding and awareness of the multiple goods and services provided by the different levels and functions of agricultural biodiversity."[11] The third element objective is to strengthen the capacity of farmers, indigenous and local communities to manage sustainably agricultural biodiversity so as to increase their benefits and to promote awareness and responsible action. The fourth element is to support the institutional framework and policy and planning mechanisms for the mainstreaming of agricultural biodiversity into agricultural strategies and action plans and into wider strategies and plans for biodiversity in general.

The COP has also launched an International Initiative for the Conservation and Sustainable Use of Pollinators to promote coordinated action worldwide to:

- monitor pollinator decline
- address the lack of taxonomic information on pollinators
- assess the economic value of pollination and the economic impact of pollinator decline
- promote the conservation and restoration and sustainable use of pollinator diversity in agriculture and related ecosystems.

National implementation

Most of the countries that have submitted national reports to the COP have included references to agricultural biodiversity. Of the 111 national reports thus far submitted, 58 provide fairly significant coverage of agriculture and/or agricultural biodiversity.[12] The scope of coverage is variable, however, with different countries focusing on different issues. Very few countries describe comprehensive policies, programmes or strategies for agricultural biodiversity, though a number do indicate they plan to develop these.[13] In addition, the Global Environment Facility (GEF) has established an Operational Program and Guidelines on agrobiodiversity which explicitly notes the possibility of funding for this kind of specific strategy or plan.

Intellectual Property Rights

Relevant provisions

Article 16 concerns technology transfer and is the only article that explicitly mentions intellectual property rights. The article is complex and ambiguous and full of internal cross-references. Because of its ambiguity, Article 16, perhaps more than others, can only really begin to take shape through the experience established through implementation. Perhaps the most relevance to the GR professional will come from how these provisions in light of the CBD objectives can be implemented at the national level in harmony with the TRIPS Agreement (see Chapter 6).

Article 16 addresses access to and transfer of technologies that are relevant to the conservation and sustainable use of biological diversity or make use of genetic resources and are subject to intellectual property rights. The article aims at striking a balance between the need to secure access and technology transfer on the one hand, and the respect of intellectual property rights, on the other. In such a case, the access and transfer shall be provided on terms which recognize and are consistent with the "adequate and effective protection" of intellectual property rights (Article 16.2). However, the Contracting Parties shall cooperate "subject to national legislation and international law in order to ensure that such rights are supportive of and do not run counter to its objectives" (article 16.5).

In addition, each Contracting Party undertakes to take legislative, administrative or policy measures, as appropriate, with regard to intellectual property, the handling of biotechnology and the distribution of its benefits, with the aim that:

- Contracting Parties, in particular those that are developing countries, which supply genetic resources are provided access to and transfer of technology which makes use of those resources, on mutually agreed terms, including technology protected by patents and other intellectual property rights, where necessary, through the provisions of Articles 20 and 21 and in accordance with international law and consistent with paragraphs 4 and 5 of Article 16 (Article 16.3)
- the private sector facilitates access to, joint development and transfer of technology referred to in Article 16.1 for the benefit of both governmental institutions and the private sector of developing countries and in this regard shall abide by the obligations included in paragraphs 2 and 3 of Article 16 (Article 16.4)
- an effective participation in biotechnological research activities is ensured to those Contracting Parties, especially developing countries, which provide the genetic resources for such research (Article 19.1)
- It is promoted, and advanced priority access is given on a fair and equitable basis by Contracting Parties, especially developing countries, to the results and benefits arising from biotechnologies based upon genetic resources provided by those Contracting Parties. Such access shall be on mutually agreed terms (Article 19.2).

Finally, each Contracting Party shall, directly or by requiring any natural or legal person under its jurisdiction providing any living modified organism resulting from biotechnology, provide any available information about the use and safety regulations required by that Contracting Party in handling such organisms, as well as any available information on the potential adverse impact of the specific organisms concerned to the Contracting Party to which those organisms are to be introduced (Article 16.4).

Implementation issues of note

In relation to intellectual property rights, the Bonn Guidelines adopted at the 7th meeting of the Conference of the Parties to the CBD:

- Invite Governments to encourage disclosure of the country of origin of genetic resources or traditional knowledge in IPR applications, where the subject matter of the application concerns or makes use of either of them in its development
- Request information gathering and analysis on the role of customary laws and practices, and the feasibility of an internationally recognized certificate of origin as evidence of PIC and MTA
- Request information on national mechanisms for obtaining PIC of indigenous and local communities
- Invite WIPO to prepare a technical study on methods for requiring disclosure of genetic resources, the country of origin, traditional knowledge and its source, and evidence of PIC
- Encourage participation of indigenous and local communities.

Article 8: *In situ* conservation

Relevant provisions

Article 8 of the Convention requires each Contracting Party to implement several measures, in order to ensure the *in situ* conservation of genetic resources (see Box 5.1), but leaves a great degree of discretion to each Party. This article provides the main set of Convention obligations to conserve biological diversity and recognizes *in situ* conservation as the primary approach for biodiversity conservation. The article addresses the conservation of ecosystems, wild species and genetic diversity. It also covers the *in situ* conservation of domesticated plant varieties and animal breeds. As discussed in section II above, Article 8(j) addresses indigenous and local communities.

Implementation issues of note

The Conference of the Parties will be considering a Global Strategy for Plant Conservation

Box 5.1. *In situ* conservation (Article 8)

Each Contracting Party shall, as far as possible and as appropriate:

(a) Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;

(b) Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;

(c) Regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;

(d) Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;

(e) Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;

(f) Rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, *inter alia*, through the development and implementation of plans or other management strategies;

(g) Establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health;

(h) Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species;

(i) Endeavour to provide the conditions needed for compatibility between present uses and the conservation of biological diversity and the sustainable use of its components;

(j) Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices;

(k) Develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations;

(l) Where a significant adverse effect on biological diversity has been determined pursuant to Article 7, regulate or manage the relevant processes and categories of activities, and

(m) Cooperate in providing financial and other support for *in situ* conservation outlined in subparagraphs (a) to (l) above, particularly to developing countries.

at its 6th meeting in April 2002. The Strategy aims to provide a framework to facilitate harmony between existing initiatives aimed at plant conservation, to identify gaps where new initiatives are required and to promote mobilization of the necessary resources. A number of subobjectives are identified, including:

- understanding and documenting plant diversity by monitoring the status and trends in global plant diversity and its conservation, identifying plant species at risk, developing accessible information systems and promoting research
- conserving plant diversity by long-term conservation, management and restoration of plant diversity *in situ* and *ex situ*
- using plant diversity sustainably by strengthening measures to control unsustainable use and by supporting the development of livelihoods based on the sustainable use of plants including the fair and equitable sharing of benefits derived from this use
- promoting education and awareness about plant diversity
- building capacity for the conservation of plant diversity by enhancing human resources, physical and technological infrastructure and linking actors to maximize action and potential synergies in support of plant conservation.

Article 10: Sustainable use of components of biological diversity

The sustainable use of biological diversity is one of the Convention's primary objectives. Article 10 is the focus of the Convention's sustainable use requirements (though as Table 1 illustrates (see Chapter 1), Article 8—particularly subparagraphs (c) and (i)—also emphasizes sustainable use). Article 10 (b) is the key provision and requires parties to adopt measures related to the use of biological resources to avoid or minimize adverse impacts on biological diversity.

International implementation generally

GR professionals may wish to note that the CBD provides for periodic meetings of the Parties to monitor and make decisions regarding implementation and these may have relevance to PGRFA. In addition, the CBD provides for a set of institutions to support the elaboration of its obligations. In addition to the Secretariat and the Conference of the Parties, there is also a Subsidiary Body on Scientific, Technical and Technological Advice, a Clearinghouse Mechanism for Scientific and Technical Cooperation and a financial mechanism operated by the Global Environment Facility.

Since the CBD entered into force in 1993, its implementation has proceeded slowly. In the CBD, governments have found it difficult to bring together the many disciplines and policy measures needed to achieve the Convention's objectives. Different governments select different priorities from among the broad array of possible initiatives within the scope of the CBD. Only a few specific national regulations have been enacted so far to implement the provisions of the CBD. However, many countries are considering legislation on the matter.[14]

Endnotes

1 The term "Contracting Parties" is used in the Treaty to denote countries that have formally ratified the Treaty.

2 Under the framework established by the International Undertaking on Plant Genetic Resources (IU) (1983), plant genetic resources for food and agriculture (PGRFA) were deemed a "common heritage of mankind" and subject to a system of free exchange among the parties to the IU ("Plant genetic resources are a common heritage of mankind to be preserved, and to be freely available for use, for the benefit of present and future generations", Preamble). The CBD has substantially changed this approach, as examined below.

3 For the purpose of the Convention, the "genetic resources being provided by a Contracting Party" are only those that are provided by Contracting Parties that are countries of origin of such resources or by the Parties that have acquired the

genetic resources in accordance with the Convention (Article 15.3).

4 Article 29 of the “Bonn Guidelines”, UNEP/CBD/COP/6/6, page 20. Other relevant sections of the Bonn Guidelines, as far as traditional knowledge is concerned, are 17, 24(d) 42(g).

5 The following categorization is partially based on Lyle Glowka, 1999 (Towards a certification for bioprospecting activities. Study commissioned by the State Secretariat for Economic Affairs).

6 For instance, the National Environment Management Act, 1994 (Law No. 13/94) of **Gambia** empowers the competent national authority to prohibit or restrict any trade or traffic in any component of biological diversity (Article 32.g). It contains a specific provision (Article 35) on access to genetic resources, according to which “the genetic resources of the Gambia shall constitute an essential part of the natural wealth of resources of the people of the Gambia”. A Council created by the law may make regulations and prescribe guidelines regarding access to the genetic resources of The Gambia, including "(1) measures regulating the export of germplasm; (2) measures for sharing of benefits derived from germplasm originating from The Gambia, and (3) fees to be paid for access to germplasm”.

7 For example, in **Cameroon**, law 94/01 of 20.1.94 sets forth rules for an integrated management, conservation and sustainable utilization of forests, fauna and fisheries. It provides that genetic resources of Cameroon belong to the State. Nobody is allowed to exploit them for scientific, commercial or cultural purposes without authorization. The financial or economic benefits resulting from their utilization are subject to a royalty to be paid to the State, at a rate and upon modalities of payment to be determined by the Minister of Finances, on the basis of proposals by the competent ministers (Article 12).

8 The research community has also criticized the need to obtain the informed consent of communities in whose territories research will be conducted, as “unrealistic and costly”. That requirement, however, finds strong support from other stakeholders.

9 According to its transitional provisions, Decision 391 applies to those persons and institutions “that possess genetic resources for which Member States are countries of origin” and obliges them to request access to the National Competent Authority. Moreover, contracts already entered into between State organizations and third parties which are not in conformity with the Decision may be renegotiated or not renewed, as appropriate. These rules apply to any “*ex situ* conservation centre”.

10 For example, *see,*III/11; IV/6.

11 DecisionV/5; http://www.biodiv.org/decisions, page 7.

12 http://www.biodiv.org/programmes/areas/agro/reports.asp

13 *Ibid.* See also UNEP/CBD/SBSTTA/5/INF/10

14 For instance, the Organisation of African Unity has adopted a draft model legislation covering access to genetic resources which is under consideration in some African countries. See also the draft Indian Biodiversity law.

VI. Origin and movement of PGR: implications for access and benefit-sharing policies

Introduction

In the best of all worlds, good policy is based on good science. And in the best of all worlds, the science is clear and unambiguous and capable of providing relevant information and insights. In the real world, however, "science" often yields to politics in policy and law-making processes.

Technical and scientific considerations persist into the implementation phase, when policies must be operationalized and when laws must be interpreted, implemented and enforced. If the dissonance between science and policy is too great, pressures can build and eventually lead to changes in policy.

This section seeks to establish a common scientific base for our discussion of policies and laws by looking at certain topics that are central to contemporary policy and legal debates, *inter alia*, the concept of "origin" (including centres of origin and diversity) and the current location of genetic diversity, the nature of contemporary germplasm flows, and the degree of interdependence among nations for genetic resources.

Origins

N.I. Vavilov's legacy is a powerful one. The pioneering Russian scientist postulated the existence of eight major centres of origin of cultivated plants. These centres exhibited tremendous diversity of a complex of crops. While Vavilov never used the term "centre of diversity," we now recognize that Vavilov's centres were indeed centres of diversity that in many, but not all cases, corresponded to centres of origins for *groups* of crops.

In 1971, Jack Harlan published the first major critique of Vavilov, putting forth the view that there were centres and "non-centres" of domestication, some "centres" being so large or diffuse as to render the term meaningless.[1] Shortly thereafter he observed that "it is becoming increasingly apparent that some [crops] do not have discernible centres either of diversity or of origin and that many have originated in areas outside of the centres of origin postulated by Vavilov….Our studes have shown that most crops indigenous to Africa did not arise in a centre of origin in any conventional sense of a centre, and that the same situation is likely to have occurred in Southeast Asia and Oceania and in South America."[2]

As discussed in Chapter 5, the Convention on Biological Diversity places great store in the feasibility of identifying a "country of origin" of a species or a particular genetic resource. It is the country of origin and only that country, according to the Convention, that is entitled to negotiate and approve terms of access with another party. This approach, designed primarily to deal with rare, endemic species of potential pharmaceutical or chemical value, is of less utility when it comes to dealing with domesticated species.[3] The Convention specifies that the country of origin of domesticated and cultivated species is the country where the species or the genetic resource (the Convention is unclear as to which it is) developed its distinctive properties in *in situ* conditions.

Given the prominence of the Vavilov Centres of Origin, it may have appeared to negotiators of the Convention that identification of a country of origin of wheat, for example, would be as straightforward as ascertaining the country of origin of a rare orchid found in the Brazilian rain forest. This is not the case, however. In effect, Vavilov postulated regions of origin (domestication) for groups of crops; the Convention speaks of countries of origin for specific "distinctive properties" of a particular crop, a far more precise criterion.

It is well known that crops were domesticated over vast expanses of land and over a long period of time.[4] Pinpointing the location where a specific property arose (perhaps 10 000 years ago) may be difficult or impossible. Moreover, most properties come in gradients—there are different shades of red apples, different degrees of disease resistance, etc. The existence of secondary centres of

diversity—such as sub-Saharan Africa for maize—reduces the value of using the Vavilov centres as the sole tool in determining "origin" as used in the Convention.

The Vavilov legacy undoubtedly influenced even the negotiations on the International Treaty on Plant Genetic Resources for Food and Agriculture. In these negotiations, delegates established a multilateral system for some 35 crops and a number of forages, obviating the need (as in the Convention) to identify a precise country of origin for these materials. But, the remaining crops—hundreds of them—will henceforth be handled under the terms of the Convention on Biological Diversity. Delegates implicitly assumed that satisfying the requirements of the Convention—identifying the country of origin of specific distinctive properties—was routinely feasible. Given what is known—and what is not known—about centres and about the precise location of origin of particular properties found within a domesticated crop, one might question whether Vavilov centres will prove to be very useful in pinpointing locations where those specific properties first arose. On the surface, this would appear to be a case where "the science" and the current state of knowledge were inadequately understood during the treaty-negotiating process, and where its limitations will become manifest as countries attempt to implement both the Convention and the Treaty.

The current location of diversity

Erna Bennett, a pioneer in the genetic resources field, once jokingly remarked that if Vavilov were to redraw his maps, he would have to designate Ft. Collins, Colorado, as a centre of diversity. Ft. Collins is the location of the National Seed Storage Laboratory, one of the largest genebanks in the world. The observation is an appropriate one in the context of policy and law-making in which countries attempt to pair "access" with "benefit-sharing" in a manner that depends on the laws of supply and demand. While it is certainly true that all genetic resources originally came from *in situ* conditions, it is equally obvious that much of that diversity can no longer be found "in the field", *and* that a great deal of diversity can now be accessed from genebanks far removed from any Vavilov centre. As Table 6.1 reveals, some of the best potential "customers" for PGRFA are also in a position to be the biggest suppliers or sellers. The implication, the lesson to be learned, is that access and benefit-sharing schemes designed to regulate current transactions need to take into account not so much the historical location of materials as their present location and status.

One also needs to consider the quality of the collections and of the associated information that can be provided about them. Many collections located within Vavilov centres, or developing countries more generally, are of relatively less utility than their numbers might indicate, having been compromised over the years by less than adequate conservation practices and facilities.[5] Need for regeneration is often high, for example, an indicator that storage conditions may be poor and that diversity may have already been lost.

Crop experts also believe that much of the existing diversity has already been collected and is in genebanks. This is particularly the case with major crops such as rice, wheat and maize. FAO estimates that 95% of the landraces of these crops can be found in *ex situ* collections.[6] Of course, landraces continue to evolve in the field, giving the possibility that new genetic combinations, or mutations, of value will arise. Conversely, genetic erosion is also taking place, giving the possibility that existing (and new) materials will be lost.

All of these considerations must be taken into account when assessing which sources are and will be most important in supplying genetic resources for future breeding programmes. Data provided here indicate, however, that much diversity exists and can be easily accessed from sources outside

Table 10.1. Genebanks and accessions in *ex situ* collections, by region[a]

Region	No. of accessions	% of Total	Genebanks	% of Total
Africa	353 523	6	124	10
Latin America and Caribbean	642 405	12	227	17
North America	762 061	14	101	8
Asia	1 533 979	28	293	22
Europe	1 934 574	35	496	38
Near East	327 963	6	67	5
Total	5 554 505	100	1308	100
CGIAR	593 191		12	

[a] FAO. 1998. The State of the World's Plant Genetic Resources for Food and Agriculture. FAO, Rome, Italy.

traditional Vavilov centres, a situation that may undermine the "market" position of "countries of origin" under the Convention.

Germplasm transfers

Academic work on contemporary germplasm transfers reinforces the view that *ex situ* collections "in the public domain" are important as sources of materials for both developed and developing countries.[7] CGIAR centres, for example, distribute some 100 000 samples per year.

There is also strong evidence that access from *ex situ* sources far exceeds access from *in situ* conditions, if collecting by CGIAR centres is any indication of the overall situation.[8] CGIAR centres now add substantially fewer than 5000 accessions (predominantly but not exclusively from *in situ* sources) to their collections per year, less than 5% of the amount that is distributed from their *ex situ* holdings.

In addition, the fact that CGIAR centres have "restored" germplasm in recent years to at least 41 countries that had previously provided the same accessions to the centres, is evidence that countries themselves are losing materials (and thus, would not be in a position to provide them or to benefit from providing them).

In terms of crops excluded from the FAO Treaty's multilateral system, one of the tradeoffs that negotiators made was this: they "gave up" any Treaty-mandated collective benefits that would have been generated from existing *ex situ* (and *in situ*) collections of these crops in exchange for benefits they hope individual countries will be able to capture from providing access bilaterally to these materials under the framework of the Convention on Biological Diversity. Once again, however, the objective reality may intervene. Establishing the country of origin (as defined by the Convention) may prove difficult. Most materials may already be in storage and in the public domain outside of those countries. And, there may be little relative demand for, or current economic value associated with, materials found exclusively in *in situ* conditions.

Given these "realities", countries are faced with both a number of options and a number of dilemmas. They may wish to consider (1) how they will secure access to the materials they need in an efficient and cost-effective manner, and (2) how they will provide access to materials they have in a way that maximizes benefits to themselves. These goals may prove to be somewhat contradictory in practice, leading to a third option, which is to consider cooperative measures. This third

option assumes (1) that countries are interdependent in terms of genetic resources, and (2) that access is important—or will become important—to all.

Interdependence

No country is predominantly independent in terms of PGRFA. For the same reason that few, if any, countries are the sole source of genetic resources for a particular crop, all countries depend on others, even for access to materials of native crops. Many countries, however, have agricultural systems based chiefly on crops that were domesticated elsewhere, and on genetic resources supplied by others.

Countries in southern Africa, for example, fall between 65% and 100% in their dependence on main food crops that originated outside the region, with most countries exceeding a 90% dependency level.[9] Generally, dependency is higher for developed than for developing countries, though often the levels are remarkably similar. According to FAO, Italy has a dependency level of 71–81%. The country that most closely matches this level is Ghana with a dependency of 70–81%.[8]

Dependency on *crops* that originated outside of the country should not, however, be confused with dependency on *access* to those crops. As we have already seen, the source of genetic resources of a particular crop might bear little relation to the region or the country where the crop originated.

Interdependency is graphically illustrated by looking at the pedigrees of modern varieties of major food grains, for instance. The wheat cultivar, Sonalika, which was planted on over 6 million hectares in developing countries in 1990, had a pedigree drawing on materials acquired from no fewer than 15 countries.[8] Sonalika is far from being unique. Major spring bread wheats (those planted on more than 0.25 million hectares) in the developing world in 1997, *on average* had 50 landraces in their known pedigree and were the result of nearly 2000 parental combinations.[10]

Several conclusions or inferences can be drawn from such data:

(1) Clearly, both international and national programmes use large amounts of material, and modern agricultural systems are based on genetic resources supplied by many countries.

(2) Assigning an economic value to individual accessions would be difficult given the number of accessions used and the number of crosses made. This difficulty, combined with other factors such as the spread of crops over 10 000 years, the ease of duplication, and the multiplicity of sources, explains the historic absence of a market for PGRFA as a commodity.

(3) Benefits can be captured, however, even if the genetic resource is not directly sold as such as a commodity. Materials are used in breeding programmes, value is added in the research process, and countries, farmers and consumers benefit by having better and more productive varieties. Byerlee and Traxler estimate that the benefits from wheat breeding for spring bread wheat alone in the developing world were approximately US$2.5 billion annually by the late 1980s.[11] None of this benefit, interestingly, is accounted for by income generated by providing access to PGRFA. Arguably the principal value of the resource is as a resource, not as a commodity. One of the challenges now faced by policy-makers is thus how to develop appropriate policies based on this understanding.

While "access" is obviously critical to plant breeding programmes, it is also critical to farmers who use improved seeds and planting materials. Both directly and indirectly, it is important to *all* countries, even to those without active plant breeding programmes in a particular crop. There is no example of a country being able to develop its agricultural system on the basis of reliance on either indigenous crops or on genetic resources sourced locally. Countries that are at

all looking toward the future and are at all optimistic about or desirous of creating a prosperous agricultural system must be appreciative of the value of having access to genetic resources from others.

Conclusion

Struggles over crops, planting materials and genetic resources, are ancient. Countries and interest groups have long maneuvered to gain advantage from the flow of genetic resources. Various strategies have been employed, some collective, some highly individualistic. Successful management of PGRFA in the 21st century will certainly benefit from a knowledge of this history, but it will benefit even more from an understanding of current realities and current needs. In this section of the manual, we have looked at the ability of modern science (or reasonably modern theories such as Vavilov's) to underpin certain approaches to managing access and benefit-sharing, e.g. those of the Convention on Biological Diversity and, in relation to crops excluded from the multilateral system, of the International Treaty on Plant Genetic Resources. Since plant breeders access materials not from history books but from existing collections and sources, we asked where genetic diversity can be found and most easily obtained today. The conclusions we arrived at were further confirmed by data on germplasm flows. Finally, we looked at the nature and degree of dependence that countries have on outside sources of germplasm.

Strong policies and beneficial laws are founded on good science. Implementation, to a large extent, absolutely depends on it. Policies and laws predicated on anything less than a solid factual basis contain "structural faults" that will lead to unanticipated consequences, and probably to their own undoing at some point in the future. This section has looked at certain key issues that will affect how policies and laws (including the new International Treaty on Plant Genetic Resources) will be implemented. In so doing, we hope to have laid the groundwork for a discussion about how well such policies and laws will achieve their own objectives, in light of the fact that their drafting may not always have taken sufficient account of certain "realities" discussed in this section. How then, can future policies and laws—and implementation of existing international agreements—be improved to achieve, for example, the admirable goals of the International Treaty?: the conservation and sustainable use of PGRFA and the fair and equitable sharing of benefits arising out of their use, while supporting effective management of these precious resources at all levels.

Endnotes

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2 Harlan, J.R. 1975. Geographic Patterns of Variation in Some Cultivated Plants. J. Heredity, Vol. 66.

3 Fowler, C. 2000. Protecting Farmer Innovation: The Convention on Biological Diversity and the question of origin. Jurimetrics, Vol. 41.

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VII. The TRIPS Agreement

Relevance to genetic resources managers

Scope

The TRIPS Agreement is one of the agreements of the WTO adopted in 1994 at the close of the Uruguay Round of negotiations under the General Agreement on Tariffs and Trade (GATT). It entered into force in 1995, simultaneous with the inauguration of the WTO, the creation of which was also an outcome of the Uruguay Round. The TRIPS Agreement obliges all WTO Member countries to comply with minimum standards of protection of intellectual property. It does not establish a world intellectual property right system.[1]

The Agreement covers patents, copyrights, trademarks, industrial designs, geographical indications, integrated circuits and undisclosed information. It does not specifically deal with breeders' rights (a *sui generis* form of protection for plant varieties).

Article 27.3(b): Protection of plant varieties

The Article of most direct potential relevance to GR professionals is Article 27.3(b), which deals with exclusions from patentability and in its contents sets up a requirement for the protection of plant varieties. The provision states that Members may exclude from patentability:

> Plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof. This provision shall be reviewed four years after the entry into force of the WTO Agreement.

Article 27.3(b) gives Member States considerable flexibility in providing protection to plant varieties. They can develop *sui generis* forms of protection which do not exactly correspond to a breeders' rights model (see Chapter 7 on UPOV for an example of this type of model) to the extent that the *sui generis* regime is "effective." They can, for example, create systems that explicitly deal with the issue relating to the conservation and sustainable use of plant biodiversity. GR professionals accessing or developing new varieties need to be aware of any national laws implementing Article 27.3(b). Technical advice from GR professionals to policy-makers may have particular value here because Member States have flexibility to ensure a system that balances the public and private interests in a manner appropriate to the national situation and, as noted above, to explicitly deal with issues relating to the conservation and sustainable use of plant biodiversity. The design of a *sui generis* regime can also take into account the peculiar features of each national seed supply system as well as the national context and the international instruments relating to the access and use of PGR. These include the CBD and the IT.

Despite the flexibility to frame a regime for the protection of plant varieties and to determine the scope, level and form of protection to be conferred, such a regime would have to comply with the minimum standards established by the TRIPS Agreement. First, the regime would therefore need to recognize the national treatment principle whereby like products are treated the same regardless of their orgin. Second, it would also have to respect the most-favoured nation standard, which requires that any advantage accorded to nationals of a WTO member country has to be extended to any other member country. Third, the regime would also have to confer "effective" protection. This qualification—contained in the body of Article 27.3(b)—is ambiguous since no criteria are established to judge the effectiveness of the Agreement. It could be argued that the qualification goes not to the

level of protection but to the availability of legal mechanisms to enforce them (as required by Part III of the TRIPS Agreement). Finally, in the absence of an exception, the protection should also be granted to varieties of all genera and species.[2]

Other relevant provisions

As an Agreement setting minimum standards for intellectual property, TRIPS may also have general relevance to GR professionals involved with access to and/or development of research products or for those involved with providing technical advice to policy-makers. A familiarity with its key provisions and how these have been interpreted by the national government is therefore useful.

WTO Members may exclude animals and plants (even if genetically modified), animal races and plant varieties from the patent system. They must, however, ensure protection to microorganisms, and non-biological processes and microbiological processes and, as noted above, plant varieties, either by patents or by an effective *sui generis* system (or some combination of both.)

The TRIPS Agreement does not define what an "invention" is. Member States have followed different approaches on this matter, particularly in relation to biotechnological inventions. Thus some (e.g. the United States) admit the patentability of biological materials if claimed in isolated form. Others (e.g. Brazil, the Andean Group) require that the material be genetically modified in order to be patentable.

Exceptions to the exclusive rights conferred by patents are permitted (Article 30). Member countries may, for instance, establish exceptions for research and education and, as allowed in Europe, for commercial experimentation on a patented invention. They may also allow parallel imports under the doctrine of international exhaustion.[3]

The TRIPS Agreement specifically permits the granting of compulsory licences[4], such as in cases of emergency, anti-competitive practices and for non-commercial governmental use (Article 31). The grounds on the basis of which such licences can be granted are not limited by the Agreement.

As noted in Chapter 2, technically there is no hierarchy in types of international regimes be they trade, environment or development-oriented. Nevertheless, in practice, the WTO trade agreements are likely to carry more weight because of a dispute settlement mechanism with the possibility of sanctions. Non-compliance with the provisions of TRIPS may be the basis of a dispute settlement procedure as established by the Dispute Settlement Understanding (DSU). If a violation is determined, the complaining Member may impose on the infringing Member commercial retaliatory measures.[5]

Implementation issues of note

The Ministerial Meeting of WTO which took place at Doha, Qatar in November 2001 adopted a Ministerial Declaration and the Decision on Implementation-Related Issues. Each of these contains a section on the TRIPS Agreement covering three areas: geographical indications, Article 27.3(b) and technology transfer to least-developed countries. While the provisions do not contain any new commitments in the sense of norm-creating, the decision could ultimately result in a negotiation that goes beyond the mere clarification of existing rules.[6]

The Ministerial Declaration acknowledges that issues relating to the extension of the protection of geographical indications to products other than wine and spirits will continue to be discussed by the TRIPS Council. It does not commit members to resolution, however. The use of geographical indications has been an important issue for countries concerned with misappropriation of high-value goods. Countries that have been seeking additional protection are mainly from Asia, Europe and Africa. They include countries such as Thailand and India that have complained about what they

see as a misappropriation of high-value goods, namely jasmine and basmatic rices. For these countries the GI issue is important because they can be used to promote the export of valuable products and prevent misappropriation.

Article 27.3(b) was also discussed at the Doha meeting. The TRIPS Council was ultimately instructed to "examine, *inter alia*, the relationship between TRIPS, the Convention on Biological Diversity, the protection of traditional knowledge and folklore and other relevant new developments raised by members pursuant to Article 71.1".[7] No explicit commitments were made with regard to traditional knowledge and folklore but its inclusion in the Ministerial Declaration indicates the issue is now mainstream.

Endnotes

1. The Agreement included transitional provisions that allowed developing countries and economies in transition to delay its implementation, particularly in relation to the patenting of pharmaceutical and agrochemical products. However, the general transitional period for adaptation to the Agreement's provisions expired on 1 January 2000. Least-developed countries can delay the implementation of the Agreement until 2006 and thereafter request for additional extensions.
2. Note the contrast to UPOV (see Chapter 7). UPOV 1978 does not require protection for all genera and species; UPOV 1991 does provides for transitional periods for new members (Article 3).
3. Doctrine according to which a patent holder "exhausts" his/her rights after the first legitimate sale of the patented product in a country, region or on the international market. See article 6 of the TRIPS Agreement.
4. Compulsory licence is the authorization given by a judicial or administrative authority to a third party for the use of a patented invention, without the consent of the patentee, against payment of a compensation to the right-holder.
5. There has been so far no decision under WTO relating to Article 27.3 (b). However, the USA initiated consultations with Argentina relating to the patentability of microorganisms. See WTO document WT/DS196/1.
6. Bridges, Vol. 1, No. 1, 22 November 2001; http://www.ictsd.org/biores/01-11-22/story3.htm
7. Article 71.1 deals with review of implementation of the Agreement, including with a possible view to modifying or amending it.

VIII. UPOV

Relevance to GR managers

UPOV is a *sui generis* form of intellectual property protection designed specifically for the protection of plant varieties. UPOV sets forth standards, including national treatment, for the granting of "breeders' rights". It is TRIPS compatible. There are four versions of UPOV. Until recently both the 1978 and the 1991 versions were open to new members. The 1991 version entered into force on 24 April 1998, technically closing the 1978 version to new members.[1] As of 1 April 2002, there are 50 States party to UPOV (Table 8.1).

Provisions

In order to be eligible for protection, a plant variety must meet the following requirements:

(i) **Novelty**. UPOV 1978 does not speak of novelty per se. That is introduced in 1991. The variety must not—or, where the law of a State so provides, must not for more than one year—have been offered for sale or marketed with the consent of the breeder in the State where the applicant seeks protection, nor for more than four years (six years in the case of grapevines and trees, including rootstocks) in any other State. The 1991 Act makes the one-year period of grace compulsory and requires that "propagating or harvested material of the variety" must not have been "sold or otherwise disposed of to others".

(ii) **Distinctness.** The variety must be clearly distinguishable by one or more important characteristics from any other variety whose existence is a matter of common knowledge.

(iii) **Uniformity.** Subject to the variation that may be expected from the particular features of its mode of propagation, the variety must be sufficiently uniform.

(iv) **Stability.** Subject to the variation that may be expected from the particular features of its mode of propagation, the variety must be stable in its essential characteristics.

(v) **Denomination.** The variety must be given a denomination enabling it to be identified; the denomination must not be liable to mislead or to cause confusion as to the characteristics, value or identity of the new variety or the identity of the breeder.

As noted in Chapter 2, the evolution of UPOV reflects the general trend toward the strengthening of the rights granted. The growth of biotechnology and the possibility of formal patent coverage created pressure leading to the 1991 revision of UPOV, which:

(1) Extends the rights of holders beyond the reproductive material to the harvested material and products obtained through illegal use of propagating material.

(2) Allows members the option to allow "dual protection", i.e. simultaneous patent or UPOV-style protection for the same material. This had not been provided for under UPOV 1978.

(3) Extends coverage to cover all plant genera and species.

The Convention provides for the so-called "right of priority". Any breeder (national or a resident of a member State) may file his or her first application for protection of a given plant variety in any of the member States. If the breeder files an application for the same variety in any other member State within 12 months of the filing of the first application, this "later" application will benefit from the right of priority.

Protection is granted after the competent authority of the member State in which protection is sought has ascertained that the subject plant variety fulfils the above criteria.

According to the Convention, as amended in 1991, there are seven acts of exploitation for which the breeder's authorization is required: (1) production or reproduction (multiplication); (2) conditioning for the purpose of propagation; (3) offering for sale; (4) selling or other marketing; (5) exporting; (6) importing, and (7) stocking for any of these purposes.

Table 8.1. States party to UPOV, as of 1 April 2001[a]

State	Date on which State became member of UPOV	No. of contribution units	Latest Act[b] of the Convention to which State is party and date on which State became party to that Act	
Argentina	December 25, 1994	0.5	1978 Act	December 25, 1994
Australia	March 1, 1989	1.0	1991 Act	January 20, 2000
Austria	July 14, 1994	1.5	1978 Act	July 14, 1994
Belgium[c]	December 5, 1976	1.5	1961/1972 Act	December 5, 1976
Bolivia	May 21, 1999	0.2	1978 Act	May 21, 1999
Brazil	May 23, 1999	0.25	1978 Act	May 23, 1999
Bulgaria	April 24, 1998	0.2	1991 Act	April 24, 1998
Canada	March 4, 1991	1.0	1978 Act	March 4, 1991
Chile	January 5, 1996	0.2	1978 Act	January 5, 1996
China	April 23, 1999	0.5	1978 Act[d]	April 23, 1999
Colombia	September 13, 1996	0.2	1978 Act	September 13, 1996
Croatia	September 1, 2001	0.2	1991 Act	September 1, 2001
Czech Republic	January 1, 1993	0.5	1978 Act	January 1, 1993
Denmark[e]	October 6, 1968	1.5	1991 Act	April 24, 1998
Ecuador	August 8, 1997	0.2	1978 Act	August 8, 1997
Estonia	September 24, 2000	0.2	1991 Act	September 24, 2000
Finland	April 16, 1993	1.0	1991 Act	July 20, 2001
France[f]	October 3, 1971	5.0	1978 Act	March 17, 1983
Germany	August 10, 1968	5.0	1991 Act	July 25, 1998
Hungary	April 16, 1983	0.5	1978 Act	April 16, 1983
Ireland	November 8, 1981	1.0	1978 Act	November 8, 1981
Israel	December 12, 1979	0.5	1991 Act	April 24, 1998
Italy	July 1, 1977	2.0	1978 Act	May 28, 1986
Japan	September 3, 1982	5.0	1991 Act	December 24, 1998
Kenya	May 13, 1999	0.2	1978 Act	May 13, 1999
Kyrgyzstan	June 26, 2000	0.2	1991 Act	June 26, 2000
Mexico	August 9, 1997	0.75	1978 Act	August 9, 1997
Netherlands	August 10, 1968	3.0	1991 Act[g]	April 24, 1998
New Zealand	November 8, 1981	1.0	1978 Act	November 8, 1981
Nicaragua	September 6, 2001	0.2	1978 Act	September 6, 2001
Norway	September 13, 1993	1.0	1978 Act	September 13, 1993
Panama	May 23, 1999	0.2	1978 Act	May 23, 1999
Paraguay	February 8, 1997	0.2	1978 Act	February 8, 1997
Poland	November 11, 1989	0.5	1978 Act	November 11, 1989
Portugal	October 14, 1995	0.5	1978 Act	October 14, 1995

Table 8.1. (cont.)

State	Date on which State became member of UPOV	No. of contribution units	Latest Act[b] of the Convention to which State is party and date on which State became party to that Act	
Republic of Korea	January 7, 2002	0.75	1991 Act	January 7, 2002
Republic of Moldova	October 28, 1998	0.2	1991 Act	October 28, 1998
Romania	March 16, 2001	0.2	1991 Act	March 16, 2001
Russian Federation	April 24, 1998	0.5	1991 Act	April 24, 1998
Slovakia	January 1, 1993	0.5	1978 Act	January 1, 1993
Slovenia	July 29, 1999	0.2	1991 Act	July 29, 1999
South Africa	November 6, 1977	1.0	1978 Act	November 8, 1981
Spain[h]	May 18, 1980	1.5	1961/1972 Act	May 18, 1980
Sweden	December 17, 1971	1.5	1991 Act	April 24, 1998
Switzerland	July 10, 1977	1.5	1978 Act	November 8, 1981
Trinidad and Tobago	January 30, 1998	0.2	1978 Act	January 30, 1998
Ukraine	November 3, 1995	0.5	1978 Act	November 3, 1995
United Kingdom	August 10, 1968	5.0	1991 Act	January 3, 1999
United States of America	November 8, 1981	5.0	1991 Act[j]	February 22, 1999
Uruguay	November 13, 1994	0.2	1978 Act	November 13, 1994

[a] Source: www.upov.int (UPOV Web site).
[b] "1961/1972 Act" means the International Convention for the Protection of New Varieties of Plants of 2 December 1961, as amended by the Additional Act of 10 November 1972; "1978 Act" means the Act of 23 October 1978, of the Convention; "1991 Act" means the Act of 19 March 1991, of the Convention.
[c] With a notification under Article 34(2) of the 1978 Act.
[d] With a declaration that the 1978 Act is not applicable to the Hong Kong Special Administrative Region.
[e] With a declaration that the Convention of 1961, the Additional Act of 1972, the 1978 Act and the 1991 Act are not applicable to Greenland and the Faroe Islands.
[f] With a declaration that the 1978 Act applies to the territory of the French Republic, including the Overseas Departments and Territories.
[g] Ratification for the Kingdom in Europe.
[h] With a declaration that the Convention of 1961 and the Additional Act of 1972 apply to the entire territory of Spain.
[j] With a reservation pursuant to Article 35(2) of the 1991 Act.

The above-mentioned rights may be exercised in respect of the propagating material, and also in respect of the harvested material (including whole plants and parts of plants), provided that the latter has been obtained through the unauthorized use of propagating material, and that the breeder has had no reasonable opportunity to exercise his or her right in relation to the propagating material.

The breeder's right extends, in addition to the protected variety itself, to varieties which are not clearly distinguishable from the protected variety, which are "essentially

derived" from the protected variety,[2] and those whose production requires the repeated use of the protected variety. This issue is dealt with in the 1991 UPOV.

As in the case of UPOV 1978, under UPOV 1991 the underlying genetic resource embodied in a protected plant variety is freely available to third parties for the purpose of breeding ("breeders' exemption"). This is crucial for the further improvement of existing varieties. On the other hand, under UPOV 1978 farmers were permitted to save seed for re-use in their exploitations. UPOV 1991 made this exemption optional for members. Member States which are party to the 1991 Act may except farm-saved seed from the breeder's right, within reasonable limits and subject to safeguarding the legitimate interests of the breeder. Some States have chosen to give farmers an unconditional right to replant seed from their previous harvest, while others have limited this right to certain crops or to small farmers.The UPOV Convention also allows access to and the use of protected material without the consent of the titleholder in cases of public interest, against an equitable remuneration.

Endnotes

1 Although new members to UPOV can only join the 1991 Act, many countries still remain obliged under the 1978 Act of the Convention.

2 A variety which is essentially derived from a protected variety and which fulfils the criteria of novelty, distinctness, uniformity and stability, may be the subject of protection by a third party but cannot be exploited without the authorization of the breeder of the original variety. The concept of essential derivation applies to varieties which are predominantly derived from another variety and which, except for the differences that result from the act of derivation, conform to the initial variety in the expression of the essential characteristics that result from the genotype or a combination of genotypes of the initial variety (Article 14.5 of the UPOV Convention, 1991 Act).

IX. Phytosanitary and biosafety measures

Relevance to genetic resource managers

The movement of PGRFA typically involves small quantities of living materials—packets and packages as opposed to truck or ship loads. Nevertheless, such transfers are regulated by international and national law designed to prevent the introduction of disease and pests and to minimize the threat posed to native plants and animals from exotic species. GR professionals involved with accessing and distributing PGRFA across national boundaries need to be familiar with the international and national regulations relevant to this transfer. GR professionals who also provide advice to ministries of health and agriculture must also be aware of the sensitivities and issues related in particular to biosafety and genetically modified organisms.

There are three principal international agreements in this area that are relevant to genetic resource managers, research directors and national policy-makers: the International Plant Protection Convention, the World Trade Organization's Sanitary and Phytosanitary Agreement, and the Cartagena Protocol on Biosafety. This Chapter looks at each, briefly, and notes instances where policy is fluid and where the relationship between agreements is less than certain. While all of these agreements purport to be based on "science", it should be noted that political and economic considerations are never far below the surface in any discussion of how transfers of agricultural produce and products, seeds, planting materials, etc., will be regulated.

Phytosanitary measures and why they are important

The distribution of plant genetic resources (PGR) brings with it risks to plant health, biological diversity, and potentially human health too. Up to the present day, the overriding concern in the movement of living plant material is the parallel spread of diseases into new areas and their damaging impact on agricultural production. Increasing genetic uniformity in crops has accentuated the potential effect of diseases. The potato famine in Europe and North America in the 19th century is a famous example. The fungus, *Phytophthora infestans,* completely wiped out potato crops and was responsible for the death by starvation of 1 million and the emigration of another 1.5 million poor people in Ireland alone.[1]

In a similarly important vein, the introduction of infections to collections of germplasm can be highly detrimental to the viability of plant material in both the short and long terms. Infected germplasm from genebanks can corrupt the results of research, characterization and evaluation studies, and bring about genetic erosion in genebanks, multiplication plots and other field sites.[2] The consequences of such failures in PGR conservation and research are, of course, grave, especially for important collections containing a large part of the world's diversity of specific crop species.

Although less prominent, alien invasive species are also of concern because of their far-reaching effect on natural ecosystems. Numerous plant species, often crop plants or ornamentals, have been transported throughout the world by humans. Their attractive characteristics frequently include adaptability and hardiness. Invariably as humans have colonized and re-colonized more remote places (oceanic islands are some of the most notable examples) their chosen plants have expanded rapidly into delicately balanced native ecosystems to the detriment of native species. Species of pine, guava, *Passiflora*, *Leucaena*, *Cecropia*, *Rhododendron*, *Rubus*, *Miconia*, etc. are just a few of the burgeoning numbers of invasive species which have spread around the world and contributed significantly to the loss of biological diversity. As an extension of this phenomenon, genetically modified organisms have been recognized as a vector or a new form by which foreign and potentially invasive genes may be introduced into a new environment.

The benefits of introducing new germplasm to a continent, country or province, therefore, must be weighed against the risks posed and the costs of managing such risk. Levels of risk differ with the origin, age, volume, type and identity of plant material and the characteristics of the receiving territory or body. Vegetative propagules, especially where roots and soil are included, pose a greater risk than seeds in transmitting pathogens.[3] The nature of the packing material also can increase the risk of transmitting disease.

All such risks are alleviated through quarantine measures: regulating the form and nature of incoming material, eliminating high-risk material or subjecting it to quarantine and therapy. These controls are exerted at a national level. However policy has existed at an international level, since at least the 19th century, with the aim of coordinating phytosanitary measures to improve biosafety over wider areas. Existing legislation is largely focused on transboundary movement and quarantine procedures. In terms of plants, there are three main agreements of relevance: the International Plant Protection Convention (IPPC) which is, to date, the most important and the oldest international agreement, the World Trade Organization (WTO)–Sanitary and Phytosanitary (SPS) agreement, and the Cartagena Protocol on Biosafety. Invasive species are poorly regulated but their control is a requirement of signatories to the Convention on Biological Diversity (CBD).

The aims and main features of national and international regulations are summarized below. In brief, the IPPC provides an international framework for the harmonization of national phytosanitary measures. The WTO-SPS aims at preventing the misuse of phytosanitary regulations as a barrier to trade and works closely with the IPPC. The Cartegena Protocol on Biosafety has a wholly different function. Its aim is very specific: to safeguard biodiversity from the potential dangers of GMOs.

National and international plant protection regulations

National phytosanitary regulations

Almost all countries regulate incoming plant material because of the risk of pests and pathogens for agriculture. National phytosanitary regulations are in place in compliance with the IPPC. They usually:

(1) Specify prohibitions
(2) Grant exceptions for scientific purposes
(3) Require import permits
(4) Require phytosanitary certificates and/or certificates of origin
(5) Stipulate inspections upon arrival
(6) Prescribe treatment upon arrival to eliminate risks
(7) Prescribe quarantine, post-entry quarantine, isolation or other safeguards.[4]

Both small assignments of germplasm and bulk shipments of commercial material involve a potential risk. There are, however, important differences between the two. Germplasm assignments are generally small and have a relatively high value. The costs of applying therapy and testing procedures are, therefore, more reasonably absorbed. However, additional precautions may be necessary where either the germplasm itself or the area of origin is poorly studied from a pathological perspective. Detection of poorly characterized pathogens, particularly viruses, requires specialized tools. The procedure of exporting germplasm should, therefore, be specific to the species. A joint FAO–IPGRI programme is set up to generate crop-specific guidelines for disease-indexing and other phytosanitary measures, including the listing of important pests and diseases of concern. The guidelines are focused specifically on the movement of germplasm and are intended to provide scientific information to national quarantine authorities and to scientists wishing to exchange germplasm (Table 9.1). They are not intended for commercial shipments of seeds or other plant material and they have no officially recognized status.

Table 9.1. Crops covered in the series of published FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm

Allium spp.	*Eucalyptus*	Small grain temperate cereals
Cacao	Grapevine	Stone fruits
Cassava	Legume	Sugar cane
Citrus	*Musa*	Sweet potato
Coconut	Potato	*Vanilla*
Edible aroids	Small fruits	Yam

International Plant Protection Convention

This legally binding convention aims to promote legislative and other measures to control the spread of pests of plants and plant products, including any organism, object or material capable of harbouring plant pests (Table 9.2). The secretariat is hosted by FAO and 113 governments are party to the agreement. Under the Convention, provisions exist for:

- A national organization for plant protection (whose responsibility it is to inspect plants, including those in storage, as well as to manage the safety aspects of the international traffic of plants)
- Phytosanitary certification
- Phytosanitary measures
- Regulation of pests.

Amendments were adopted at the FAO Conference in 1997, which take account of the role of the IPPC in relation to the WTO–SPS Agreement. As a result a Commission and with a Secretariat are now formally established with the role of developing and adopting international standards. Although the standards are not legally binding, it is largely through their adoption that SPS measures are shaped.

The WTO and SPS

Since the creation of the General Agreement on Tariffs and Trade (GATT) international legislation has existed to protect plant, animal or human health where it is under risk from the introduction of traded goods. However the concern that this legislation was open to abuse as an unnecessary barrier to trade gave rise to more recent agreements on Technical Barriers to Trade (TBT) and SPS measures. The two are complementary; the first sets down relevant technical requirements including labelling and inspection requirements, the second obliges parties to base SPS measures on science-based risk assessment. Parties are able to define their own SPS measures, but they should conform to standards adopted by the commission of the IPPC. Any more restrictive measures must be consistent and justifiable scientifically.

The Biosafety Protocol

In response to growing concerns about genetically modified organisms, parties to the CBD adopted in January 2000 a subsidiary agreement, the Cartagena Protocol on Biosafety. Despite its name, this agreement is devoted solely to the safe transfer, handling and use of living modified organisms (LMOs—i.e. living GMOs), particularly concentrating on their importation and international movement. It does not cover the introduction of exotic species in general, nor other products of biotechnology which have not been genetically modified. Like the CBD, the Biosafety Protocol is focused on safeguarding biological diversity, but human health is also a consideration.

LMOs (with the exception of those contained in pharmaceuticals) which are new to a country and are undergoing the first intentional introduction are covered by the protocol.

Table 9.2. International Standards for Phytosanitary Measures (ISPMs)

No.	Title	Date/Status
ISPM 1	Principles of Plant Quarantine as Related to International Trade	1995, under revision (2002)
ISPM 2	Guidelines for Pest Risk Analysis	1996, under revision (2002)
ISPM 3	Code of Conduct for the Import and Release of Exotic Biological Control Agents	1996
ISPM 4	Requirements for the Establishment of Pest Free Areas	1996
ISPM 5	Glossary of Phytosanitary Terms	1999
ISPM 6	Guidelines for Surveillance	1997
ISPM 7	Export Certification System	1997
ISPM 8	Determination of Pest Status in an Area	1998
ISPM 9	Guidelines for Pest Eradication Programmes	1998
ISPM 10	Requirements for the Establishment of Pest Free Places of Production and Pest Free Production Sites	1999
ISPM 11	Pest Risk Analysis for Quarantine Pests	2001
ISPM 12	Guidelines for Phytosanitary Certificates	2001
ISPM 13	Guidelines for the Notification of Non-Compliance and Emergency Action	2001
ISPM 14	The Use of Integrated Measures in a System Approach for Pest Risk Management	2002
ISPM 15* Suspended	Guidelines for Regulating Wood Packaging in International Trade	2002
ISPM 16	Regulated Non-quarantine Pests: Concept and Application	2002
ISPM 17	Pest Reporting	Under development

Two prominent features of the protocol are: (1) the Advanced Informed Agreement (AIA) procedure, whereby importing countries agree to receive LMOs from exporting countries, and (2) the Biosafety clearinghouse mechanism, which will act as an information exchange resource. Importantly the AIA process excludes LMOs intended for direct use as foods or feeds or for processing (known as LMOs–FFPs), LMOs in transit and those bound for contained use (contained use being a form of physical structure with specific measures to prevent contact with the external environment). A simplified procedure also exists to allow importing countries to accept specified LMOs and bypass the AIA procedure. Meanwhile, the transboundary movement of LMOs–FFPs is monitored and documented through a considerably less demanding process. Shipment of all LMOs, including those in transit or destined for contained use, are to be identified as such. Details on the taxonomy, origin and characteristics of donor and parent organisms, and other data on handling and storage, may also be demanded. The exact details of the process are still under discussion.

The AIA mechanism involves the notification, decision-making and, if needed, the review of decisions by countries exchanging LMOs that are destined for anything other than direct use as food, feed or for processing or for contained use. The decision-making process, particularly the assessment of risk, is specified in some detail. Importing countries may take up to a year after notification by the exporter to come to some kind of decision. The exporter may be liable for the costs of undergoing the decision-making process.

AIA procedure
Notification by party of export
(max 90 days) ➔
Acknowledgement of receipt
(max 270 days) ➔
Communication of decision

The protocol also imposes basic requirements for parties to ensure that measures are in place to manage risks posed by any LMO to biodiversity. This includes the imposition of a period of observation on newly developed or newly introduced LMOs, according to the life cycle of the organisms involved, before they are put to use.

The protocol is still to come into force, and the exact form of the major elements is in the process of being consolidated. To date it has been signed by almost 100 countries. Although the USA, Uruguay and Australia have not signed the agreement, other major exporters of GMOs have. Its relation with other forms of international regulations (e.g. the WTO) is ambiguous. The preamble of the Protocol states that obligations to other international regulations remain unaltered, but that the protocol should not be considered subordinate to other agreements.

Conclusions

Controls on the movement of germplasm are mainly geared to prevent the spread of pests and diseases and are exerted through phytosanitary regulation at the national level. International policy attempts to harmonize these controls and ensure that their use is not employed as a barrier to trade. More recently conceived policy, in the form of the Cartagena Protocol, will govern the movement of LMOs through clear identification of shipments and a system of the notification and decision-making between importers, exporters and an information clearinghouse mechanism.

Endnotes

1 http://www.geocities.com/willboyne/nosurrender/PotatCom.html . FAO. 1998. The state of the world's plant genetic resources for food and agriculture. FAO, Rome, Italy.

2 Frison, E.A. 1991. Phytosanitary aspects of genebank management. Pp. 53-59 in Proc. Inter-Centre Meeting on Germplasm Health and Movement, October 1990, Rome. International Board for Plant Genetic Resources, Rome.

3 Kahn, R.P. 1977. Plant quarantine: principles, methodology and suggested approaches. In W.B. Hewitt and L. Chiarappa (eds.). Plant health and quarantine in international transfer of genetic resources. CRC Press, Cleveland.

4 Ibid.

Web site addresses of the Conventions

Convention on Biological Diversity	http://www.biodiv.org/
Cartagena Protocol on Biosafety	http://www.biodiv.org/biosafety/
International Plant Protection Convention	http://www.ippc.int/IPP/En/default-htm
World Trade Organization—Sanitary and Phytosanitary Measures	http://www.wto.org/english/tratop_e/sps_e/sps_e.htm
World Trade Organization—Technical Barriers to Trade	http://www.wto.org/english/tratop_e/tbt_e/tbt_e.htm

X. Development and improvement of genetic resources

Relevance to genetic resource professionals

Intellectual property issues may arise in the acquisition, characterization and distribution of germplasm. One of the inherent characteristics of germplasm is that it is a tangible or real object that can be used consumptively like other natural resources. And like other natural resources issues related to ownership, issues dealing with sharing and access can arise. But germplasm is also used as a source of information: the genetic information found in the chromosomes of the nucleus and associated subcellular structures of the plant or animal. This information can be employed to develop useful synthetic compounds or as a source of desirable genetic traits. It is the latter characteristic that has combined with scientific advances and led to the worldwide expansion of intellectual property (IP) regimes over genetic resources.

Intellectual property issues may involve formal (statutory) IPRs and/or IPRs arising from contractual obligations. Formal IPRs come about as the result of an assignee or inventor filing an application for protection of IP. The IP could be something such as an invention or germplasm, and the filing will need to be done under a national regulation, such as a filing for plant variety protection (PVP) under a PVP regulation or rule.[1] A successful application for PVP will lead to IPR, usually referred to as Plant Breeder's Rights (PBR). In addition, it is possible that specific germplasm will have other types of IPR associated with it, such as patent rights or a trademark registration. Having patent IPR associated with germplasm may happen if a developer of germplasm has used a patented technology—such as a method or a material—in the development of a new germplasm. A trademark may be associated with a particular identification that can be valuable as a marketing tool. Genetic resources managers need to know whether there are formal IPR associated with germplasm that is in their collection. Such IPR may affect or restrict the ability of a genetic resources manager to distribute such germplasm.

Intellectual property "protection" essentially means that third parties can be prevented from producing or selling goods or services using such information without the title-holder's authorization. Unlike physical property, intellectual property rights are temporary, with the exception of trade secrets (which are protectable as long as they remain undisclosed) and trademarks, the protection of which can be extended limitless.

Depending on national laws, patents, one of the most important forms of intellectual property, may be applied to genes, cells, microorganisms and different classifications of plants and animals. In some countries (e.g. the United States), patent protection may cover both biological materials found in nature, to the extent that they have been isolated and purified, as well as those produced with genetic engineering. In other countries (e.g. Brazil), however, protection can not be granted with respect to biological materials which preexist in nature, even if isolated. Breeders' rights are a form of protection specifically conceived to protect plant varieties.[2] It is important to note that the availability of the product for further research differs between most patent systems and systems conferring plant breeders' rights. Research exemptions allowing the use of a protected product tend to be quite narrow in patent law. Under UPOV and other systems of PBR, the protected varieties remain available for further breeding (for a fuller discussion see Chapter 7). Also, as mentioned in Chapter 6 of this manual, countries may also develop other effective *sui generis* regimes for that purpose.

Intellectual property rights are normally owned by individuals and private entities. Collective rights of indigenous peoples and local communities[3] with respect to traditional knowledge have also been recognized in some jurisdictions. However, the delimitation and

enforcement of such rights pose considerable conceptual and operative problems. Collective rights can also be held on some forms of IP that are protected by copyright —for example, a film or video may have many copyright owners.

Non-statutory IP protection associated with germplasm often arises from an agreement or contract called a material transfer agreement (MTA), covering the material to be transferred, given or distributed. The MTA will contain provisions or terms that specify certain things about the use and/or distribution of the germplasm. Germplasm does not need to be protected by PVP or a patent or any other formal protection, in order for its distribution to be made under an MTA. It only needs to be owned or held by a genebank in order for distribution of material to be carried out under an MTA (for a discussion of MTAs under the IT, see Chapter 4).

Genetic resources managers need to be aware of what is needed to implement institutional IP guidelines. The GR professional involved in acquisition and distribution needs a clear understanding of the institution's IP policy and how it is implemented. If there is no IP policy, an understanding of first, national laws, and second, international legal obligations—such as those arising under the IT—relevant to the institution's germplasm including plans for collecting and distribution, is necessary to develop the appropriate policies and procedures. The GR managers responsible for access and distribution will likely be responsible for making sure that the necessary procedures—whether GAA, MTA or another type of agreement—are followed.[4] At a practical level, this means that managers responsible for the access and distribution of genebank material in the genebank need a database of IPR information relevant to accessions in the genebank. They also need an understanding of the implications of this information for the genebank's ability to distribute particular accessions of germplasm.

Main issues

While IPRs, particularly patents, confer exclusive rights with respect to the protected subject matter—which includes genetic materials in many countries—the CBD has recognized sovereign rights over genetic resources, including to establish conditions to collect and subsequently use for commercial or research purposes the collected materials (see Chapter 5 of this manual). Three main issues have been raised in this context: (1) the appropriation of genetic resources under IPRs, (2) the possible limitations on access to IPRs protected materials, and (3) the recognition and protection of traditional knowledge. All three of these reflect the potential or perceived tension between private property rights conferred by patents or plant breeders' rights and the application of national legislation aimed at achieving the goals of the CBD.

Appropriation of genetic resources under IPRs

As indicated, patents, as conferred in some jurisdictions, permit the appropriation of genetic materials by private entities, as such. In addition, a number of patents have been granted with respect to materials useful for agriculture or medicine known to and widely used by indigenous and local communities (such as turmeric, Bolivian quinoa and the Amazonian "ayahuasca")[5]. All this has raised concerns in many developing countries about a possible conflict between IPRs, as recognized under the TRIPS Agreement, and the provisions of the CBD[6] on access to and use of genetic resources.

The need to develop an interface between IPRs and access regulations, in order to avoid possible misappropriation of genetic resources, has led some countries to impose limitations on the IPR protection of genetic resources and associated knowledge,[7] to the establishment of special conditions for the application and granting of IPRs relating to biological materials,[8] to the provision of

compulsory licences,[9] or other conditions to encourage competition practice. However, given the territoriality and independence of patent rights, such limitations and conditions usually only prevent the granting or lead to the cancellation of IPRs in the country where the limitations or conditions were applied, but not in foreign jurisdictions.

Limitations to access

Another issue that has generated concern is the impact that the appropriation of genetic materials under IPRs, where admitted, may have on the access to such materials for further research and development. Those concerns have been fueled by the expansion of IPRs, particularly patents, to living organisms (including genes and any subcellular component) and the admission in some countries (USA, Australia, Japan) of patents on plant varieties.

As noted above, the granting of PBRs does not limit the use of the protected material as a source for further research and breeding, owing to the generally accepted "breeders' exemption". In the area of patents, opinions diverge on whether a patent would prevent a third party from commercially using a protected gene, in cases where its expression was not obtained through biotechnological means but as a result of conventional plant breeding methods.[10] This too can differ in different legal jusridictions.

Traditional knowledge

The need to develop some form of protection for communities' knowledge has gained growing recognition since the 1990s. The adoption of Article 8(j) of the Convention on Biological Diversity gave impetus to this idea (see Chapter 5 of this manual). Many approaches have been proposed to deal with communities' knowledge, ranging from the creation of new *sui generis* forms of IPRs to the simple option of legally excluding all forms of appropriation over such knowledge, be it under patents, breeders' rights or other modalities of IPRs.

Only a few countries have so far addressed the complex conceptual and operational problems involved in the recognition of the rights of indigenous and local communities over their knowledge.[11]

Acquisition and use of technology: relevance to GR access and distribution

Genetic resources managers need to acquire new material in such a way that it can be distributed in accordance with institutional IP policy at some future date.[12] It is necessary to know if technology has been used to develop the material to be acquired and whether the technology has formal or non-statutory IPR associated with it. If there are proprietary interests[13] in the technology it is necessary to know in what jurisdictions—in what countries—IPRs have been awarded, who owns the technology and the status of such ownership (for example, under assignment or licence). Copies of licence agreements for the technology that was used in the development of the material might be needed. Sometimes, tracking down all of the technology, the IPR associated with the technology and the owners of the IPR can be very complex, will involve the cooperation of many owners, and may require the use of legal assistance, as in the case of "Golden Rice"®.[14] Unless this information is known and assessed, the acquired germplasm cannot be distributed without the risk of breaking the law. If there are limitations on the access and distribution of the germplasm that are at odds with institutional IP policy, this can be made clear. Remember that IPRs are territorially limited: there is not an international patent, for example. This means that if a technology used in the development of a new germplasm has been protected only by a patent issued by the United States, then this germplasm is protected only in the USA. In other words, the germplasm cannot be used, sold, exported out of, imported into, or made

in the USA without proper authority (a licence or licences from the IPR owner/owners.) However, this material could be used, made or sold in other countries. Nevertheless, it is important to remember that there may also be agreements, such as an MTA or other contracts, that may have been signed in order to acquire the material. The terms of the MTA or other contract may specify the terms under which the material may be used, sold, made, etc., regardless of conditions that apply due to formal IPR associated with the material. These terms may preclude the distribution of such germplasm in a manner consistent a genebank's IP policy.

Lessons from the CGIAR

Background

Perhaps some of the most dramatic developments in legal and policy issues affecting the CGIAR's work have taken place in the field of intellectual property rights. This is particularly true with regard to the application of intellectual property rights to biological materials and processes. It is in this context that the CGIAR has endorsed Guiding Principles on Intellectual Property Rights and Genetic Resources recognizing that they may need to evolve in response to changing law and technology (Table 10.1).

Developments affecting the conservation, exchange and use of genetic resources include, for example, the use of intellectual property rights, most notably patenting, to protect plant varieties and their components. These developments have expanded dramatically, creating an uncertain but arguably more restrictive environment for the use and deployment of genetic resources. Methods and technologies of critical importance to the research function of CGIAR centres are also increasingly protected by intellectual property rights, rendering access and use more problematic. The rise of broad, so-called "blocking" patents raises the possibility that intellectual property rights might be employed in ways that can affect the development, improvement, access to and distribution of genetic resources in genebanks. However, thus far this has not been a problem. And of course, the conclusion of the IT also has IP implications for the CGIAR, some of which will be resolved as the treaty moves forward (see Chapter 4).

The underlying philosophy for the CG Guiding Principles is that the management of intellectual property by centres must be guided by the CGIAR mission to contribute to food security and poverty eradication in developing countries through research, partnerships, capacity-building and policy support. Any engagement with intellectual property directly or indirectly would need to be done as the best means of pursuing the CGIAR's mission. The Guiding Principles also reflect the CGIAR's view that the protection of intellectual property should not serve as a mechanism for securing recurring financial returns upon which it may depend. To the extent that such returns are generated, they are to be used in support of specific tasks and projects fully compatible with the CGIAR mission and objectives.

Specific examples of issues of general relevance

1. IP embedded in the genetic resource: Use of IP that is a part of a genetic resource (often referred to as IP "embedded" in the genetic resource) can present situations that require a careful understanding of the specifics of the particular situation. For example, if a particular type of breeding scheme, which is protected by patent IPR granted in the USA, has been used to develop a new variety of bean, this technology is a part of that particular bean germplasm. In other words, if a person grows this variety (or any variety of bean developed with the protected breeding scheme) in the USA without a licence from the owner, then this person will be committing an infringing act. He will be infringing the rights of the IPR owner and the owner of the IPR can bring a civil suit (e.g. can "sue") against the person who is growing the beans, and anyone

Table 10.1. CGIAR Guiding principles on IPRs relating to designated germplasm and centre research products

- The centres will not claim legal ownership nor apply intellectual property protection to the germplasm they hold in trust, and will require recipients of the germplasm to observe the same conditions, in accordance with the agreements signed with FAO.
- Materials supplied by the centres, whether designated germplasm or the products of the centres' breeding activities, may be used by recipients for breeding purposes without restriction. Recipients, including the private sector, may protect the products of such breeding through plant variety protection that is consistent with the provisions of UPOV or any other *sui generis* system, and that does not preclude others from using the original
- Based on the conviction that their research will continue to be supported by public funds, the centres shall regard the results of their work as international public goods. Hence, full disclosure of research results and products in the public domain is the preferred strategy for preventing misappropriation by others. Consequently, the centres will not assert intellectual property control over derivatives except in those rare cases when this is needed to facilitate technology transfer or otherwise protect the interests of developing nations. In all such cases, the centres will disclose the reasons for seeking protection.
- The centres do not see the protection of intellectual property as a mechanism for securing financial returns for their germplasm research activities, and will not view potential returns as a source of operating funds. In the event that a centre secures financial returns as a result of the commercialization by others of its protected property, appropriate means will be used to ensure that such funds are used for furthering the mandate of the centre and the objectives of the CGIAR.
- Any intellectual property protection of centres' output will be done on behalf of the centres and not individual scientists. All staff in the centres will be required to disclose innovations and assign all rights on these to the centres.
- Cells, organelles, genes or molecular constructs isolated from materials distributed by centres may be protected by recipients only with the agreement of the supplying centre. Centres will only give such approval after consultation with the country, or countries, of origin of the germplasm where this is known or can be readily identified. This consultation would include consideration of an appropriate sharing of any benefits, whether bilateral or multilateral, flowing from subsequent commercial development of the protected material,[17] and would require that the original material remains available for the public good.
- To promote the availability to developing nations of germplasm and scientific innovations that have been protected by others, the centres may enter into agreements with the holders of such rights. Acceptance of any limitations on the distribution and use of derived and associated materials would have to be consistent with the goals and objectives of the CGIAR, and the benefits of such agreements should outweigh the potential disadvantages.

in the USA who buys, sells or uses the beans grown by the non-licensed person![15] It is easy to see how the use of needed technology could—directly or inadvertently—infringe the rights of an IPR owner. Genetic resource managers need to know about any technology, especially involving embedded IP, associated with germplasm in their genebank.

2. Freedom to operate: In the dissemination or transfer of technology, reference may be made to the "freedom to operate" (FTO) that is associated with a particular seed or other genetic resource. While not a legally defined term, FTO usually means that a legal professional has looked at the terms of IPR and contracts associated with a technology or a product, in order to render an opinion as to whether infringement will occur if the technology or product is used, made or sold in a specific situation. This assessment includes terms and provisions—of formal IPR, of non-statutory IPR, of contracts, agreements and licences—associated with the IP involved in the development of the germplasm in question. The rendering of an FTO involves an understanding of what technology has been used in the development of the germplasm, a search of IP (e.g. patent) databases to determine the status of statutory IPR, an investigation of all contracts and agreements associated with the germplasm, and an understanding of the commercial situation regarding the technology used and the germplasm involved. However, sometimes an FTO may be just a quick verbal opinion, rendered by an IP attorney, based on their experience in a particular technology area. Regardless, an FTO is just an opinion and does not determine the infringement status, but only the risk of possible infringement, if the germplasm is grown, distributed, sold, etc. in a particular sovereign state. Nowadays, many institutions are requiring scientists to obtain an FTO opinion before research commences in order to prevent a situation where a research product cannot be distributed or used outside of the original laboratory where the research was performed, for fear of an infringement lawsuit.

3. Defensive protection: Another issue that may affect GR managers is IPR that is sought and obtained in order to obtain "defensive" protection.[16] In this type of situation, a developer may have applied for statutory protection only to prevent others from obtaining patent or PVP for a new invention or variety. In this way the developer can be assured that no one will be able to prevent him from practising his invention or using his newly developed variety. No country allows statutory protection for an invention or product that is not new.[18] Therefore an invention cannot be patented twice and a defensive patent ensures that an inventor will be able to use, sell, make, etc. his patented technology without fear of infringing someone else's IPR. An additional reason that inventors (or their home institutions) will seek defensive protection is to increase the leverage they have, to obtain other technologies from other IPR owners. Defensive protection may be associated with genetic resources and, as the manager, you need to know. Often the owners of this type of IPR are very willing to give out licences that are royalty-free to anyone that asks.

4. Participatory plant breeding: Participatory plant breeding—the collaboration between "formal" and "informal" breeders—efforts have been growing over the last 10 years. Nevertheless, a range of definitions of what exactly it entails still exists and, perhaps more significantly, key aspects of legal and ethical issues are only now being explored. A CGIAR–IDRC project on Participatory Plant Breeding and Property Rights is examining these issues with the goal of establishing "Best Practices" or a code of conduct to guide genetic resource professionals in their collaborative efforts with farmers and farming communities.

Intellectual Property Rights audits

Often an institution will carry out an IP audit to determine the status of IP being used and generated by their staff.

Such an audit includes assembling or making an inventory of relevant documents such as collaborative agreements and employment contracts. (A relevant document would be one that contains any language or provisions having to do with intellectual property ownership, assignment or any other dispensation; also any intellectual property such as data entered into log books or laboratory notebooks, invention disclosures, patents, patent applications, third party property, and the like.)

Then the auditors will go over each of these documents to assess the terms and conditions of each, how these terms and conditions might affect the ability of the institute to use and distribute (both their own and another's IP) and to (try to) establish ownership of each piece of IP. (This might include looking at so-called FTO issues, but likely will not include an FTO opinion, only the identification of a need for an FTO opinion to be performed.) The auditors will determine the institution's vulnerability to challenges associated with IP, ranging from infringement to duplication of other's work, to the need for defensive protection.

The auditors will create an inventory or a database of IP. Such a database, created in conjunction with an IP audit, will often, but not exclusively, concentrate on self-generated IP, usually in the form of an inventions—or invention-disclosure entries. This will depend upon the terms of reference determined by the institution. It is important to remember that this inventory will include all forms of IP—patents and patent applications, PVP certificates and applications, trademarks, copyright, databases, trade secrets, traditional knowledge, geographical indications, etc.

Another product of an IP audit will be recommendations regarding IP Management. This may include a comprehensive strategy for dealing with IP issues or may just take the form of a limited number of recommendations that can be phased in, by management, to try to meet more limited expectations. Again, the terms of reference in the contract established with the auditors will determine the extent to which the recommendations are strategic and comprehensive.

IP audits can strengthen an institution's ability to make sure that it is using "due diligence" in its use of other's IP, in protecting its own IP in compliance with its IP policies, and in collaborating with other institutions.

The terms of reference (TOR) for an IP audit of an institution that has a genetic resource should include such items as:

(a) An inventory of all agreements such as MTAs that cover individual accessions.
(b) An inventory of IP that is being used and generated by the staff of the institution.
(c) An evaluation of all procedures used by the genebank for the acquisition and dissemination of materials.
(d) An assessment of employment agreements, including those for temporary visitors, consultants, visiting scientists and scientists that have been seconded from other institutions, especially those persons that are involved with genebank operations.
(e) A determination as to the status of embedded technology associated with any accessions, and whether such status suggests that a separate investigation (to determine the risk of exposure for infringement) should be carried out. (Such an investigation may take the form of an FTO.)
(f) An assessment of licences, including licences accompanying the procurement and use of laboratory reagents and equipment, to determine whether any IP provisions would affect the acquisition and dissemination of genetic resources.
(g) Recommendations regarding the management of IP (both the institution's and other, third-party IP).

(h) Recommendations regarding legal actions, such as the filing of reexaminations or other types of challenge to IPR of others that might affect the institution's ability to distribute genetic resources.
(i) Evaluation of compliance with national and international agreements and regulations covering genetic resources and IP.

In order for IP auditors to have access to all of the materials and information that they need to carry out a good IP audit, it will usually be necessary for them to obtain access to information that the institution considers to be confidential. This might be information that the institution has marked as confidential, to protect its IPR or its ability to apply for formal protection. Or, confidentiality may be stipulated by a third party as part of an agreement or contract. In either case, the IP auditors and the institution will need to enter into a confidentiality or non-disclosure agreement to protect the rights of the institution and other third parties. This confidentiality agreement should follow conventional "best-practices" and include such items as: an appendix of material that has been disclosed to the auditors, a statement regarding how the confidential material will be used, a statement regarding ownership of information and reports that result from the audit, the time limitations associated with the access to confidential documents, a statement of whether the documents will be destroyed or returned, a statement regarding the settlement of disputes, an effective date, a termination date, etc. Such an agreement should be written with the help of a qualified attorney or lawyer. The confidentiality agreement will need to be signed by an authorized person and should be put into place before an audit is initiated.

Endnotes

1 Intellectual property can be protected by a plant variety protection certificate, a patent, a trademark/ trade dress, copyright, database right, a geographical indication, and as a trade secret, for example.

2 See Chapter 7 on the UPOV Convention.

3 See Article 8(j) of the CBD. See also the draft text of a "Draft Declaration on the Rights of Indigenous Peoples" which states that "Indigenous peoples have the right to special measures for protection, as intellectual property, of their traditional cultural manifestations, such as literature, designs, visual and performing art, seeds, genetic resources, medicines and knowledge of the useful properties of fauna and flora" (U.N.Doc.E/CN.4/Sub.2/192/33, Annex 1, para. 19).

4 As the Genetic Resources Manager, you may or may not have the ability to sign an MTA for your institution. Often, only the Director General or head of an institution will have "authorized signatory power" for an institution. However, sometimes such authorization can be formally held by other staff, such as the genetic resource manager, for specific situations, as in the acquisition and distribution of genetic resources.

5 The patenting of this kind of material has been facilitated in the United States by a "grace period" that offers extended protection for the novelty requirement. In addition, according to the US Patent Law a disclosure outside the United States of an information in a non-written form (e.g. by use) does not destroy novelty and, therefore, a patent can be granted if the other patentability requirements are met.

6 See an analysis of the submissions by developing countries to the Council of TRIPS on this issue, in GRAIN. 1999. TRIPS 27.3(b). An update on where developing countries stand with the push to patent life at WTO. March 2000. www.grain.org/publications/tripsfeb00-en.cfm.

7 For instance, the Costa Rica Biodiversity Law recognizes "the existence and validity of forms of knowledge and innovation and the necessity to protect them by means of the use of legal mechanisms appropriate for each specific case", but excludes from any kind of intellectual property protection (including community intellectual rights) the following:

- Sequences of deoxyribonucleic acid per se.
- Plants and animals.
- Non-genetically modified microorganisms.
- Essential biological processes for the production of plants and animals.
- Natural processes or cycles as such.
- Inventions essentially derived from knowledge which is associated with traditional or cultural biological practices in the public domain.
- Inventions which, to be commercially exploited through a monopoly, can affect farming or fishing processes or products which are considered

basic for the food and health of the inhabitants of the country (Article 78).

[8] For instance, Decision 391 of the Andean Group stipulates that Member countries shall not recognize intellectual property rights over genetic resources, or their derivatives or associated intangible components, when access took place in contravention to the access rules provided for by such Decision. The affected Member country can request the cancellation of granted titles. In addition, national offices competent in the area of intellectual property rights shall require proof of the approval and registration of an access contract, if they have reasons to believe that the products or processes for which protection is sought have been obtained or developed on the basis of genetic resources under the jurisdiction of Member States. The Costa Rica Biodiversity Law provides for a mandatory consultation to the Offices in charge of granting patents and PBRs in relation to inventions that "involve biodiversity elements" and requires the proof–based on a "Certificate of Origin"—that prior informed consent has been obtained (Article 80).

[9] In the Philippines, in the case of endemic species, Research Contracts must state that the technology should be made available to a designated Philippine institution and can be used commercially and locally without paying royalty (Section 5.l of the Executive Order No. 247). In Costa Rica IPRs granted on subject matter involving biodiversity shall be subject to a compulsory licence for the benefit of the State in the case of a declared national emergency, without payment to the title-holder (Article 81, Biodiversity Law).

[10] For some experts, patents on genes only protect the patent holder "against use of the gene by another biotechnologist, but leave anyone free to use and breed with organisms containing the gene naturally" (Barton, J. 1998. Economics of patent enforcement. Patents, Copyrights, Trademarks and Literary Property Course Handbook Series. PLI's Fourth Annual Institute for Intellectual Property Law. Practicising Law Institute, 532 PLI/PAT 343). Others, however, fear that neither genes nor plant varieties will be available for further development without the previous consent from the holders of intellectual property rights (Lewontin, R.C. and Santos, M.M. 1997. Current trends in intellectual property rights protection pose serious threats to future innovations in agricultural sector. Diversity 13 (2&3):25-27.

[11] For instance, the Constitution of Ecuador (1998) recognizes "collective intellectual property rights" on communities' ancestral knowledge (Article 84). The Costa Rican Biodiversity Law established a legal concept of community intellectual rights, and provided for a voluntary registration system. Under this law any pre-existing community rights shall absolutely prevent any grant of PBR or patents on the same subject matter. In Brazil, Provisional Measure 2.052-6 (21.12.2000) provides that the State recognizes the indigenous and local communities' rights to decide on the use of traditional knowledge associated with genetic resources. Said knowledge is protected against "illicit exploitation" and other unauthorized uses [Article 8(1) and (2)]. The Organization of African States (OAU) developed an African Model Legislation for the Protection of the Rights of Local Communities, Farmers and Breeders, and for the Regulation of Access to Biological Resources. The Model law proposes an explicit recognition of communities' intellectual rights, through a specific registration system, as well as the right not to allow access to the resources and knowledge under their control when access may threaten the integrity of their natural or cultural heritage.

[12] This discussion does not apply to so-called "black-box" storage.

[13] "Proprietary interests" means that the owner of the property has rights (IPR) that can be exercised in this situation.

[14] The IPR issues associated with the technology used in the development of "Golden Rice" have only recently been sorted out by the owners, after several years of analysis and compromise.

[15] A court of law (a judge or jury) will decide whether any of these parties (the grower, the buyer, the user) are guilty of infringement. A party that is an infringer will have to pay a fine to compensate the IPR owner for revenue lost, due to the infringing act. If trade secrets are involved, then criminal charges will also often be brought against the defendant.

[16] Some would argue that statutory IP protection such as PVP and patents is always, strictly speaking, of a defensive nature, in that obtaining such rights must be enforced by the owner. An IPR owner must bring a lawsuit against someone that the owner thinks is an infringer. The government of a sovereign state will not bring suit against a potential infringer of a patent or of PBR.

[17] It is recognized that this requirement for the granting of permission by a centre before a recipient can take out patent protection represents a significant departure from the current position in which the centres do not require any such permission. While this is not specifically required under the terms of the agreements

signed with FAO, nevertheless the CGIAR feels that such a requirement is needed both to protect the interests of countries of origin and to bring CGIAR policy in line with the spirit of the Convention on Biological Diversity (CBD). While the CGIAR centres can not themselves be party to the Convention, it is nevertheless recognized that the majority of CGIAR members and partner countries have signed and ratified the CBD.

[18] There are some types of statutory protection that may not include a search of prior art, before protection is awarded. For example, the awarding of some types of short-term patents in certain countries (so-called "innovation" or "petty" patents) may not require a search of the literature to determine if the invention is new. There are rare circumstances where legislation may include provisions that are unclear as to the new or novelty requirement, such as the newly enacted Indian PVP and Farmers' Rights Protection law.

XI. Cross-cutting issues

Interrelationships

In addition to needing familiarity with the provisions of the international obligations and any corresponding national implementing legislation, GR professionals also need to be familiar with the key issues arising from these instruments in general and how they link or potentially may link across instruments and institutions. The complex interrelationship among issues such as Farmers' Rights, the rights of indigenous and local communities, intellectual property rights, conservation of genetic resources, access to genetic resources and benefit-sharing from the use of genetic resources challenges the kind of neat presentation and analysis that would be useful to decision-makers. For example, while the access provisions of the CBD do not mention intellectual property rights, in practice there is a clear and very strong link. In fact, as the session on the history and origins of law in this area discussed, a catalyst to the development of benefit-sharing schemes and the mechanism of access regulation generally had to do with an imbalance between actors that benefited from intellectual property rights and those that did not benefit from property rights regimes.

National policy and law

Genetic resources professionals first need to be aware of their national policies and laws. National systems (both in response to and because of their effect on international debates) are growing more formal and complex with respect to the ownership of and access to genetic resources. In developed countries—largely as a result of private sector pressure—both the scope of what can be protected and the strength of the protection are expanding. IPR protection is expanding in the more industrialized developing countries as well. In developing countries, laws are emerging governing ownership, access and benefit-sharing. All these things are interrelated. Whether or not these policies are explicitly linked in national law, GR professionals must therefore be sensitive to the relationship between, *inter alia*:

- intellectual property rights and ABS mechanisms
- intellectual property rights and indigenous and local communities
- ABS mechanisms and indigenous and local communities
- the MLS and Farmers' Rights
- patents and plant variety protection (both in terms of national laws implementing the TRIPS Agreement and in terms of managing intellectual property rights in their work).

International policy and law

Furthermore, the GR professional must be aware of the evolution of the international "regime"and their relationship to one another. Treaties can have different but related subject matter. The CBD, for example, covers all biological diversity while the IT is only concerned with PGRFA. Treaties can also belong to different areas of international law, such as environmental law and trade law. While there is no legal hierarchy between fields of international law, in practice the WTO trade-related instruments are stronger because they contain the threat of sanctions. This threat does not exist in the CBD or the IT.

Generally, access to biological material is addressed by instruments such as the CBD and the IT and access to breeding results and genetic innovations are usually regulated by IP instruments such as the national regimes established pursuant to the TRIPS Agreement or UPOV. When dealing with access, GR professionals need to know which instrument governs. The IT governs all PGRFA,[1] the MLS only a subset established by Annex 1. At the same time, the Annex can be amended by the Parties. For PGRFA not subject to the MLS and accessed after the entry into force of the CBD, the CBD provisions apply. Another issue that may arise is

the relationship of the IT to any networks to which country or institution may belong and whether these agreements are consistent with the IT.

When dealing with intellectual property rights and the minimum standards set by international law, the relationship between instruments has been a matter of debate. Debate has gone on for years about the relationship between the CBD and the TRIPS Agreement with the Doha Ministerial Declaration asking for further examination of the relationship between the CBD, TRIPS and traditional knowledge. The CBD is ambiguous on its relationship to IPRs except that it is clear that they should be supportive of and not run counter to the Convention's objectives. GR professionals should therefore aim to manage intellectual property in a manner that is in line with national objectives and supportive of the CBD while observing the minimum standards set by TRIPS. Another area where property rights arise is with participatory plant breeding. When formal, institutional, breeders collaborate with farmer-breeders a whole host of ownership issues arise to which a GR professional must be sensitive (see Chapter 2).

Benefit-sharing

CBD

Issues of equity and benefit-sharing are the common threads underlying most of the cross-cutting issues. Benefit-sharing is one of the CBD's three objectives and is explicitly and implicitly reinforced throughout the treaty's provisions. Nevertheless, the term is never defined or given concrete operational content. In the context of access, intellectual property rights, traditional knowledge, the issue of how benefits will be generated, to whom the benefits will flow and what constitutes benefits continue to be subject to considerable debate. These issues are also at the heart of the debate on the relationship between the CBD and TRIPS.

IT: The Multilateral System

Benefit-sharing was also a major topic of debate in the context of the IT. The MLS established by the rules for access and benefit-sharing for genetic resources of a list of crops contained in an annexe to the treaty and associated information. Intellectual property rights are respected. IPRs may not be claimed, however, on material "in the form received" from the system. The precise meaning of this phrase may need to be clarified by the Interim Committee and ultimately the Governing Body to the IT. The Treaty's article on benefit-sharing recognizes that access itself is a major benefit of the Multilateral System, and states that benefits arising from the use of PGRFA under the Multilateral System should be shared fairly and equitably through a number of mechanisms, both voluntary and mandatory in nature. Contracting Parties agree, for example, to "provide and/or facilitate access to technologies for the conservation, characterization, evaluation and use of plant genetic resources…" This particular paragraph [13.2.(b)(i)] encourages the transfer of technologies including those that are essentially "embedded" in genetic materials. But, the transfer is not mandatory, and respect for property rights is specifically accommodated. Benefit-sharing in the form of a payment into an international fund at FAO is mandatory when genetic material from the system is used to produce a "product that is a PGRFA" (e.g. a line or cultivar) that is commercialized, unless this product is made available without restriction for further research and development. In effect, patenting will trigger the benefit-sharing mechanism; plant breeders' rights will not. A genebank manager accessing or receiving non-MLS material may wish to consider the value of encouraging the receipt of the material on the condition that it be treated in the same way as MLS material. In addition to simplifying and reducing administrative costs it

would assure that access and benefit-sharing arrangements were consistent with the norms established by the IT.

IT: Farmers' Rights

Issues of equity and benefit-sharing were also a catalyst to the evolution of Farmers' Rights under the IT. In the original IU debates there were those who used the term "Farmers' Rights" as a general political concept and those who interpreted it as a legal concept. Those viewing it as a legal term make proposals such as defining the rights as an alternative form of IPR covering, for example, the products of farmer selection and breeding. Those viewing it as a political concept make proposals to establish a fund to finance PGRFA conservation and development work. The IT clarifies the international implications of the term. In Article 9, Contracting Parties recognize the contribution of farmers, but state that the responsibility for the realization of Farmers' Rights rests with national governments. Each Contracting Party "in accordance with their needs and priorities…as appropriate, and subject to national legislation" agrees to take measure to protect and promote Farmers' Rights, including the protection of traditional knowledge, the right to participate in benefit-sharing, and the right to participate in making decisions at the national level regarding PGRFA. The obligations are vague and, as with the CBD, conditioned by phrases such as "as appropriate"; hence there is no commitment to do anything specific. Article 9.3 notes that "Nothing in this Article shall be interpreted to limit any rights that farmers have to save, use, exchange and sell farm-saved seed/propagating material, subject to national law and as appropriate." If the farmers have these particular rights in a national jurisdiction then there is nothing in the treaty that takes these away. On the other hand, there is nothing in the treaty that establishes these rights either. The GR professional must therefore be aware of how the issue is handled nationally.

Endnotes

[1] The IT does not, however, cover access for purposes that are not related to food and agriculture.

Annexes
Economic issues

Annex 1: Economic concepts for on-farm and *ex situ* conservation of crop genetic resources

Relevance to genetic resource managers

Genetic resource professionals are frequently asked about the value of crop genetic resources. They need to be aware that there are multiple types of economic value associated with these resources and that it is often difficult to estimate them reliably in monetary terms. This chapter summarizes in descriptive terms the economic concepts that are important for practitioners to understand as they consider strategies for conserving crop genetic resources in genebanks and *in situ*, in the fields of farmers. Selected literature in this field is also cited, though studies with empirical bases that have practical implications are only now beginning to accumulate. Section I reviews general concepts of value as applied to crop genetic resources. Sections II and III address on-farm and *ex situ* conservation, respectively.

Economic value of crop genetic resources

There is growing recognition of the importance to global society of conserving crop genetic resources for the benefit of current and future generations. Yet relatively little information has been compiled that demonstrates (in quantitative terms) the benefits from or the costs of conserving crop genetic resources by either *ex situ* or *in situ* means. What explains this deficiency? First, the topic area requires specialized, interdisciplinary expertise that is not provided in typical graduate curricula. Second, conceptual advances in estimating benefits have been hindered by the fact that crop genetic resources generate values with multiple dimensions. In turn, progress in empirical analysis has been hampered by measurement difficulties because only some of these dimensions are revealed in market prices.

The concepts that economists use to understand the multiple dimensions of value associated with crop genetic resources are described next. An economist's "taxonomy" of the values associated with crop genetic resources is presented, and some key background references are provided for those seeking detailed examples of related research.

A taxonomy of economic values

Overviews and surveys discussing the sources of economic value in crop genetic resources are numerous.[1] The economic value of gene and species interactions with ecosystems and other biological functions has also been reviewed, and a recent example is found in Nunes and van den Bergh.[2] Alongside conceptual overviews of the sources of value, several theoretical economic models have analyzed the value of genetic resources.[3]

The value derived from crop genetic resources is broadly categorized as use value and non-use value. Sometimes referred to as existence values, non-use values reflect the satisfaction individuals or societies may derive simply from knowing that something exists, independently of whether it is used.[4] It is difficult to imagine, however, that many people (other than a few specialists) derive pleasure only from being assured that crop genetic resources are housed somewhere in a genebank or grown in the fields of distant farmers. Instead, crop species are conserved precisely because they are thought to embody alleles of potential use to human society. Most value associated with the accessions in a genebank collection or crop varieties grown by farmers is derived from their use rather than their mere existence. Whether or not such resources have non-use value can be tested, however, with applied methods such as "contingent valuation".[5]

Use value includes current use value and expected future use value, as well as the value of retaining the flexibility to respond to some unknown, future event—called option value. Both current and future use values can be estimated through market prices when a product or good, such as grain or seed, is traded. We can use forms of "hedonic analysis" to ascertain the current

value for productivity enhancement of crop genetic resources embodied in crop varieties.[6] A genebank collection, in contrast to a breeder's working collection, exists to a large extent in order to respond to future, unforeseen challenges, and therefore the expected future use value of a genebank collection is an important component of its total value. We can, with some methodological difficulty and a number of caveats, calculate a present value of expected future benefits from direct use of germplasm in crop improvement. We do so by combining the probability of finding useful material with its predicted productivity benefit once it is found and incorporated into new varieties. The time required to search for and incorporate useful genes into well-adapted germplasm affects the magnitude of expected benefits in a major way because of the time value of money.

In contrast to numerous conceptual overviews or theoretical treatments of the topic, there are few published examples that use empirical data to estimate the expected value of genebank collections in crop improvement. Evenson and Gollin[7] traced the flow of rice germplasm from the International Rice Research Institute into improved varieties grown in the developing world, and estimated that adding 1000 accessions to the collection was associated with annual income of $325 million in present value terms. Gollin et al.[8] studied several cases of the search for resistance among germplasm stored in a wheat collection at the CIMMYT genebank, drawing inferences about the optimal size of collections and the conditions under which marginal accessions may or may not have high value. Zohrabian[9] estimated the lower-bound value of an additional accession in the US soybean collection in crop improvement, concluding that while the benefits may not be great in absolute terms, they more than justify the costs. Moreover, it is important to remember that there are many current and future uses of genebank accessions other than their direct use in breeding new crop varieties, such as their contribution to the generation of scientific knowledge. Findings from a recent survey of international users of the US National Plant Germplasm System illustrate this point.[10]

Option value is similar to expected future use value conceptually, but distinct from it in practice. For example, we might use the past incidence of changes in rust disease pathogens or other major pest outbreaks to predict the expected future value of certain types of accessions as sources for new sources of resistance for a known pest. However, there are some pests and other environmental events for which we have no prior knowledge at all. Accessions, and collections of accessions, can have option value related to this uncertainty—but determining its magnitude in quantitative terms is difficult.

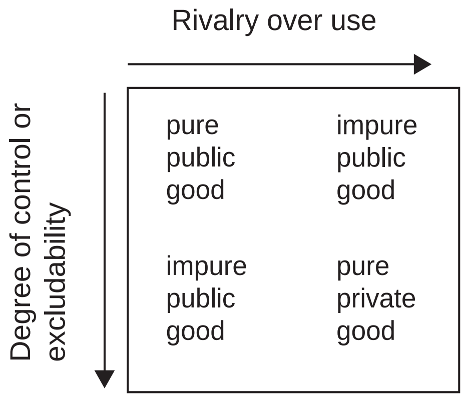
The impure public good problem

The basic economic problem for either *ex situ* or *in situ* conservation is that crop genetic resources are "impure public goods". An impure public good has both private and public economic attributes. The market prices that are typically used to value products in cost-benefit analysis generally fail to capture the full value of public goods or the public attributes of goods.

From an economics perspective all goods can be situated somewhere on two axes defined by the extent of rivalry in use and the ease or cost of excluding users. Pure private goods, such as an ice cream cone or a bag of grain, are highly rival and excludable. A bag of seed or grain is an example of a pure private good. Two people cannot use the same unit of a private good simultaneously and it is easy for one person to exclude another. Many people can use pure public goods simultaneously and excluding others is costly (Fig. A1.1a). Examples of pure public goods are the air we breathe or the genetic content of windborne maize pollen in open fields.

Note that the same seed which is private as a farm input or output is also public in terms

Fig. A1.1. Economic attributes of goods. Adapted from (a) Romer 1993[*] and (b) Sandler 1999.[†]



(a)

Characteristics of impure public goods that affect the form of institutional intervention

Characteristic		Examples
Intragenerational	Regional	Waterways
	Global	Satellite transmissions
Intergenerational	Regional	Regional fisheries
	Global	Ocean fisheries

(b)

[*] Romer, P.M. 1993. Two Strategies for Economic Development: Using Ideas and Producing Ideas, p. 72. Proceedings of the 1992 World Bank Annual Conference on Development Economics, The World Bank, Washington, DC.

[†] Sandler, T. 1999. Intergenerational Public Goods: Strategies, Efficiency and Institutions. P. 24 *in* I. Kaul, I. Grunberg and M.A. Stein (eds.), Global Public Goods. United Nations Development Programme and Oxford University Press, Oxford.

of its genetic content. Two farmers cannot benefit from the same handful of grain simultaneously, so they are rivals for its use. Yet many of both today's and tomorrow's farmers can enjoy simultaneously the benefits of the genetic codes embodied in the same seed types or varieties. As a practical matter, it is difficult for one farmer to exclude another's use of the same germplasm, particularly because the genetic content of a handful of seed or grain is to a large extent unobservable without the assistance of a laboratory and microscope. Unlike a polluted stream or a wilderness area, farmers cannot see the genetic codes in the crops they grow. Crop genetic resources, like a wilderness area and unlike pollution, are more likely to generate a desirable public good or "positive externality" rather than an undesirable, or "negative externality". Furthermore, since farmers' decisions on the use and management of crop varieties in their fields can result in smaller plant populations and the loss of potentially valuable alleles, their choices have intergenerational and interregional consequences (Fig. A1.1b).

Since genetic resources are never fully transparent to the farmers who provide and use them and are undervalued in markets, farmers are unable to consider the contributions of all other farmers to the genetic pool in their community or elsewhere when they make their decisions. Economic theory predicts that as long as a public good is a "good" (a desirable public good) as compared to a "bad" (an undesirable public good), private producers will generate less of it as a group than would be socially optimal.[11] Heisey et al. have illustrated this point for the case of diversity in crop genetic resistance to leaf rust in the Punjab of Pakistan.[12]

Economists generally argue that institutional structures are needed to compensate for

the inability of markets to provide sufficient incentives for farmers to allocate their resources in ways that are consistent with the needs of society. These structures will differ according to culture, as well as the temporal and spatial dimensions of the impure public good[13] (Fig. A1.1b). Some societies have much stronger collective behaviour than others. At the community level, depending on the social and economic conditions farmers face, community awareness campaigns may be sufficient to ensure that certain materials of genetic importance to them and to others continue to be grown. By contrast, complex structures are likely to be necessary to mediate conservation interests at the global level because actors may not perceive that they share common interests. The International Undertaking and the Convention on Biological Diversity are elements of such structures. Therefore, the extent of public investment and the policy mechanism needed to narrow the divergence between what individuals and societies perceive as optimal clearly depends on many factors.

Differences in costs of and benefits from* ex situ *and on-farm conservation

Since the 1970s, large numbers of landraces and wild relatives of cultivated crops have been sampled and stored in *ex situ* genebanks. Another form of conservation *in situ* has also received some scientific attention.[14] For cultivated crops, conservation of genetic resources *in situ* refers to the continued cultivation and management by farmers of crop populations in the agroecosystems where the crop has evolved.[15] Storing genetic resources in collections as back-up seed stocks in *ex situ* collections does not substitute for the evolution of crop plants in the fields of farmers. Crop plants grown in farmers' fields are highly vulnerable to natural and man-made disasters, compared with those conserved in genebanks. On the other hand, plant populations on farms have the capacity to support a greater number of rare alleles and different genotypes than accessions in genebanks.[16] On-farm conservation is increasingly viewed as a complement to, rather than a substitute for, *ex situ* conservation.[17] In economic terms, complementarity implies that when the genetic resources are conserved by a combination of both strategies, their expected marginal value is greater than when they are conserved by either strategy alone.

The difference in conservation goals implies that the genetic resources themselves are not directly comparable between strategies, while the distributions of their economic benefits and costs also differ in fundamental ways (Fig. A1.2). The costs of genetic resource conservation in genebanks are now borne largely by public investments, and consumers (as well as farmers who are consumers) benefit indirectly from the genetic resources incorporated into improved crop varieties because when technological change occurs, output expands and prices

Fig. A1.2. Generalized distribution of economic costs and use value from *in situ* and *ex situ* conservation.

Conservation Strategy	Greatest share of:		
	costs borne by	**use value earned in**	**use value earned by**
In situ conservation	Local farmers	Current period	Local farmers and consumers
Ex situ conservation	Taxpayers and general public	Future period	Public, in the form of knowledge Consumers, as a result of technical change

decline. Genebanks also provide other benefits to society when they serve the advancement of science through generating information about genetic resources. Characterization and evaluation information can shorten the time to incorporation of the resource into a variety that is subsequently released by a plant breeding programme or other discoveries. A large proportion of the total economic value associated with *ex situ* collections is related to expected future benefits as well as the ability to cope with as yet unknown, potentially disastrous, events.

By contrast, both the costs and benefits of conserving genetic resources *in situ* are felt directly (and in a very immediate sense) by the farmers who grow them. Consequently this form of conservation poses social and economic challenges. Certainly both *in situ* and *ex situ* conservation can generate benefits at local, national and international levels, and it is possible for genebanks to work directly with small groups of farmers in order to address their needs more directly. But this is more the exception than the norm, perhaps because there are many technological and institutional impediments that make doing so costly. It is more frequently the case for *in situ* conservation to broaden the range of materials held in an *ex situ* collection, augmenting its expected future use value. Costs of on-farm conservation involve the opportunity costs of farmers' time and in some cases, foregone development opportunities.

The following two sections discuss in more depth the economic aspects of conservation on farms and in genebanks.

Economic options to support on-farm conservation of crop genetic resources

As explained in Section I, each combination of seed types and crop management practices chosen by a farmer jointly produces (1) a crop output of food and feed with private value to the farmer, and (2) a contribution to an evolving genetic resource base of public value. Private value is measured in terms of objectives the farmer pursues for his or her own personal benefit, and is not limited to profitability. The public value of crop genetic diversity refers to the welfare of society rather than its individuals and includes (1) bequest value for future generations, (2) insurance value for potential disasters, and (3) option value for any unforeseen events, such as changes in consumer tastes.

As long as farmers themselves find it in their own best interests to grow genetically diverse crops, both farmers and society as a whole will benefit at no extra cost to anyone. In geographical locations where genetic diversity is believed to be significant but farmers are revealed to have few existing social, cultural, or market-based economic incentives to maintain it, then public investments to support conservation are necessary. Public funds are those generated by taxes or donations, transferring income from one segment of the world population to another. Economists generally believe that these forms of interventions are more "costly" to society than market-based incentives, though the expense may be justified if the size of the benefits that accrue to society outweighs the costs.[18] Whether this is true or not depends on the society, and the perceptions of social welfare held by those responsible for such decisions—or how decision-makers weigh various social goals.

Least-cost conservation of diverse crop genetic resources on farms will occur in sites that are most highly ranked in terms of public benefits and where, because the private benefits that farmers obtain from growing them is greatest, public interventions to encourage them to do so will be least. There both the costs incurred to individuals and those incurred by society in general will be relatively low.

From an economics perspective, therefore, two essential steps should precede the design of specific policy instruments to support on-farm conservation of crop plants in a particular area. First, we must ascertain, with the assistance of genetic analyses and scientific

information, in which locations crop varieties that are likely to constitute valuable resources are grown. There may be differences of opinion among breeders and conservationists about which varieties are "important" for the future needs of society. For example, some may emphasize rarity of alleles while others focus on allelic diversity. Each criterion can be measured by various techniques, including molecular analyses and agromorphological characterization.

Second, we must be able to predict the extent to which farmers in such locations have an interest in continuing to grow those varieties deemed "important". Given suitable data, micro-economic theory and applications can be used to relate explanatory factors to the likelihood that farmers will continue to grow the varieties. The next section reviews related empirical evidence, including some key references.

Evidence about farmers' incentives for on-farm conservation

We can think of the likelihood that farmers continue to grow landraces as the likelihood that they will not replace them with modern varieties. The assumption has long been made that modern varieties will inevitably replace landraces because they represent categorically a better economic opportunity. Consequently, growing landraces involves a cost in terms of foregone development opportunities. This assumption is built on some widely accepted principles concerning the process of agricultural development.

Global or regional factors: From a global perspective, several generic factors help us to begin excluding certain large geographical areas where the potential for cost-effective on-farm conservation is minimal. Broadly speaking, theory predicts and empirical research has shown that three major factors determine the likelihood that modern varieties will be more attractive to farmers than landraces: human population density, agroecology, and development of commercial markets. Human population density, or the ratio of the supply of labour to the supply of land, explains much about where the transition from low-yield, land-extensive cultivation to land-intensive, double and triple crop systems has occurred.[19] The genetic changes embodied in seed constitute one type of intensification, which refers more broadly to the increase in output per unit of land used in production (or yield).

Historical diffusion patterns for modern varieties of highly bred crops such as wheat, rice and maize illustrate this point. Predictably, the adoption of modern rice varieties in the developing world has been most complete in densely populated rice-producing areas where traditional mechanisms for enhancing yields have been exhausted.[20]

Controlling for population density, the adoption of modern rice varieties is extensive in more favourable irrigated areas and uneven in more environmentally stressful areas, which include some irrigated and many rain-fed zones. Modern varieties are largely absent in the most difficult growing environments, such as uplands and deepwater areas. Similarly, since the initial adoption and rapid diffusion of the first semi-dwarf varieties of wheat in the irrigated areas of the Asian subcontinent during the 1970s, more widely adapted descendants of these varieties spread gradually into environments less favoured for wheat production and rain-fed areas. Today, wheat landraces are cultivated extensively only in portions of the drier production zones of the West Asia–North Africa region and highlands of Ethiopia.

Among the three highly bred, major cereals, maize has the lowest proportion of area in the developing world planted to modern varieties. One explanation involves the relationship of germplasm to agroecology. For many of the environments in which maize is grown, suitable improved materials have not been developed by centralized breeding programmes.[21] The maize germplasm that performs well in temperate climates of

industrialized countries cannot be introduced directly into the non-temperate regions of developing countries without considerable additional breeding for adaptation.[22] A second explanation involves the relationship of the crop reproduction system to the commercial seed industry. Since maize is a predominantly open-pollinating crop, farmers who seek to maintain the yield advantages associated with modern varieties of maize are reliant on commercial seed in a way that rice and wheat growers are not—since they must frequently replace the seed.[23] Most modern varieties of maize are hybrids. Even if adaptation problems could be overcome through breeding, farmer demand for costly hybrid seed in developing countries remains limited because many remain subsistence-oriented and have cash-flow problems.

In general, commercialization implies that (1) production and consumption decisions of farm households are separated and mediated across markets, and (2) product choice and input use decisions are based on the principles of profit maximization. Commercial farmers trade the output of specialized enterprises produced with purchased inputs for the attributes they demand on markets where transactions are impersonal. Agricultural production as a whole is reorganized from many units, each of which reduces a similar set of crops and livestock products into fewer, specialized units, each of which produces a single crop or livestock product. The opportunity costs of producing staple food, and of stocking a wide portfolio of varieties and crops that suit specific seasonal niches and consumption needs, rises with competing demands for farmers' time.

The three broad factors described above would lead us, when considering large regions and highly bred crops, to focus on relatively more geographically and commercially isolated, less densely populated subregions with difficult growing environments. It is important to recognize that these factors would not necessarily apply to less highly bred crops that occupy other economic roles in developing countries, such as either home-grown species that fulfil specific dietary needs (famine crops in Africa) or highly valuable commercial crops produced for specific market niches, such as ornamental flowers.

Local and community factors: Regional factors such as the agroecology of a crop production zone or the development of commercial infrastructure affect the range of choices made by each of the farmers who reside in a region, though these factors are not affected in a significant way by the specific conditions of any one farm or the deliberate actions of any one farmer. Within regions that contain several candidate sites, such as a region within a country or an upland area that spans national boundaries, detailed empirical work is necessary to analyze variation among communities and farmers on a much smaller scale, in order to identify the sites where on-farm conservation is most likely to succeed.

Even on smaller geographical scales, agroecological factors play an important role in the intraspecific diversity of the crops farmers grow, through the varieties they choose and how they manage the crop and its seed. The relationship of environmental heterogeneity to crop diversity has a stronger basis in the genetics and ecology literature.[24] Ethnobotanical research has shown that farmers choose varieties based on adaptation to soils and other environmental factors.[25] Environmental heterogeneity has also been advanced as an explanation of farmers' continued use of landraces in Turkey.[26] Heterogeneity in agroecological conditions increased the number of different crops and the varieties of maize, beans, and squash varieties grown by farmers in the state of Puebla, Mexico.[27]

An extensive micro-economics literature on variety adoption and a growing set of case studies about on-farm conservation provide us with information about the types of social and economic contexts that may lead to a higher probability of conservation

of genetic diversity. The first obvious factor, which is as important on a local as on a regional scale, is the extent to which villages and households trade their crop on markets, or the extent to which their crop production is commercially oriented. The more removed a household is from a major market centre, the higher the costs of buying and selling on the market and the more likely that the household relies primarily on its own production for subsistence.

Case studies demonstrate that in many of the regions of the developing world where landraces are still grown, either markets for commercially produced seed, markets for the crop output, or markets for the multiple attributes that farmers demand from their varieties are incomplete.[28] This means that the traits demanded by farmers (grain quality, fodder, suitability for a certain soil type) cannot be obtained through the production of modern varieties or procured through impersonal market transactions, so that farmers must rely on their own or neighbours' production for their supply.[29] To meet their demands from their own farm production, they may need to grow several varieties.

Cultural identity shapes the tastes and preferences for the traits of food prepared from a crop. When the crop is consumed in the communities where it is produced, food and culinary preferences are in turn expressed in farmers' selection criteria and in the crop's genetic structure. Ethnobotanists and anthropologists have extensively documented the specialized uses of certain landrace varieties for rituals and festivals of cultural significance, though micro-economic approaches and models are less well-equipped to establish the linkage between culture and diversity. Brush[30] and Zimmerer[31] have described the role of cultural preferences for diversity in the continuing cultivation of landraces. Brush[32] proposes that sites with a high degree of cultural autonomy and an orientation toward subsistence cultivation are likely candidates for on-farm conservation.

More ambiguous is the relationship of other social and economic variables, such as household wealth and income sources, to crop diversity. Smale *et al*. found that variety attributes such as suitability for food preparation (tortillas) far outweighed the importance of household socioeconomic characteristics in explaining the number of maize landraces grown by individual farmers and the average share of maize area planted to each.[33] In three sites in Nepal, based on a composite variable for wealth rank, Rana *et al*. found that poor households cultivate more coarse-grained, drought-tolerant varieties of rice, while wealthier households grew high-quality varieties for premium market prices and special food preparations.[34] In the state of Puebla, Mexico, Van Dusen[35] found that the greater the wealth of the household, as measured by house construction and ownership of durable goods, the less likely the household is to plant a diverse set of maize, beans, and squash varieties.

In many parts of the developing world, off-farm migration generates a growing proportion of the income of farm households. Brush *et al*. found that off-farm employment was negatively associated with maintenance of potato diversity in the Andes, indicating that the opportunity cost of cultivating many varieties—which requires labour-intensive seed selection and procurement tasks—is significantly higher where other employment opportunities exist.[36] van Dusen found that diversity in the milpa system decreased as local labour markets intensify, or as more migration to the USA occurs, though these effects were not as pronounced when each crop was considered singly. Yet off-farm income can also release the cash income constraint faced by some farmers, enabling them to shift their focus from growing varieties for sale to growing the varieties they may prefer to consume. In Chiapas, Mexico, Bellon and Taylor[37] found that off-farm employment was associated with higher levels of maize diversity. Meng[38] found the existence of off-farm

labour opportunities to have no statistically significant effect on the likelihood of growing wheat landraces in Turkey.

This brief summary demonstrates that social and economic criteria are important in determining the likelihood that farmers will choose to continue cultivating diverse local crops. Though the effects of incomplete local markets for crop products and market distance seem fairly predictable, the effects of other economic variables, such as the extent of off-farm employment, income and wealth status, are not easy to predict *a priori* unless researchers already have extensive knowledge about farmer decision-making and local economies among candidate sites. Typically, it will therefore be necessary to undertake more empirical research at the household and community levels once candidate sites have been identified, in order to target households and communities for conservation programmes.

Options to support on-farm conservation

Policies may be classified as either related to (1) the demand for or (2) the supply of genetically diverse or distinct crop landraces.[39] Below we provide some illustrative examples from developing countries, though many of these initiatives are new and their efficiency in meeting conservation goals given the level of investment required has not yet been assessed in published literature.

Demand-related policies: When markets are less fully developed or they are incomplete, the demand for distinct landraces reflects primarily the concerns of local farmers who grow and consume them rather than the tastes and preferences of distant urban consumers. Farmers' demand for local landraces of genetic importance can be enhanced by improving landrace traits they identify as important, including disease resistance, abiotic tolerance, and palatability as food or fodder. Using participatory methods, plant breeders can work with farmers to identify the advantageous and disadvantageous traits of their landraces and either select superior local materials or transfer a preferred trait from exotic into local materials.[40] Participatory breeding can require substantial time investments by farmers, however.[41] A recent analysis in the state of Oaxaca, Mexico, showed that farmers as a group obtained nearly a 4:1 benefit–cost ratio from participating in a breeding project, although from the perspective of a private investor, benefits are not likely to justify the cost.[42] Furthermore, many public benefits of the project would be exceedingly difficult, as well as costly, to document. The study raises issues concerning the application of standard economic methods in similar situations, and it is important to recognize that participatory projects have goals other than generating a high economic rate of return on invested capital.[43] Participatory breeding projects exhibit a range of philosophies, approaches and goals, and only some are undertaken with the goal of enhancing crop genetic diversity.

As incomes rise and commercial markets develop, landraces may continue to be grown when there is consumer demand for some unique attribute that cannot be easily bred into or transferred to improved varieties. Advanced agricultural economies are characterized by growth in demand for an array of increasingly specialized goods and services. When consumers are willing to pay price premiums for products that are made from traditional ingredients or with traditional methods, and these products can be readily identified either by their appearance or by labeling, there may be market-based incentives for on-farm conservation of certain landraces—though these markets are likely to be small. In general, though the income elasticity of demand (percentage change in quantity demanded for a percentage change in income) for staple grains may be low or even negative, the income elasticity of demand for attributes of the grains is higher.

For example, high-income consumers spend more on rice by paying higher prices for varieties with preferred eating quality which they substitute for the lower-quality variety consumed when the income level was lower.[44]

Two types of market demand in advanced economies have been discussed as potentially relevant to on-farm conservation of genetic resources. One is the consumer demand for attributes related to the mode of production or seed type, such as organic farming methods or absence of genetically modified organisms. Another is the demand for a unique flavour, colour, or cooking quality found in a traditional crop or variety. Brush[45] reports an example of a successful "green marketing" programme for ancestral maize of Cherokee farmers in the USA. The widespread implementation of ecoseals[46] in the USA suggests that they are perceived as an effective method of altering consumer behaviour, though scant empirical research has been conducted on the optimal labeling form for different products or the effectiveness of alternative programmes.[47] Falcinelli[48] describes how labeling systems may promote conservation of farro (einkorn, emmer, spelt) and lentils in Italy. Restricted labeling systems have long been used to ensure consumer quality and authenticity for meat, cheese and wine products in Europe.

Labeling and marketing systems require public investments unless consumers are willing to pay price premia large enough to cover the costs, and require fully commercialized, well-articulated markets for product attributes. Therefore it will take time before they are likely to be effective in many developing country contexts. For example, Gauchan *et al.* found that except for traditional Basmati (aromatic high-quality) rice, most rice landraces in upland Nepal are traded in small-scale informal channels in which market signals for their superior qualities are weak relative to those expressed for modern varieties.[49] Furthermore, if such attributes are linked to specific landraces, these landraces must be readily identifiable and their attributes maintained through careful seed multiplication and production. In some countries, landraces that are heterogeneous may be blocked by seed regulations concerning uniformity.

In either advanced or developing economies, public awareness initiatives can serve to increase farmer and consumer knowledge about the benefits generated by on-farm conservation, enhancing their demand for products and seed. In Nepal, Vietnam, and the Andes, diversity fairs have been used to bring together farmers from one or more communities in order to exhibit the range of materials they use and raise awareness of the value of crop diversity.[50] Rather than awarding prizes for the best individual variety (e.g. on the basis of yield or size), diversity fairs award farmers or cooperatives for the greatest crop diversity and related knowledge. In some communities, gatherings similar to diversity fairs are already customary events, so the incremental costs are low. Though such initiatives are gaining popularity in donor and NGO seed projects, there appears to be little evidence concerning their cost-effectiveness or impact.[51]

Supply-related policies: In more isolated areas or more difficult growing environments of developing countries, agroecological and environmental factors exert a more decisive influence on crop genetic diversity than commercial markets. From one year to the next, farmers may lose their seed stock due to disastrous harvests, or diminishing seed quantities may narrow the genetic diversity in the variety. Initiatives aimed at supporting the range and total supply of local seed types make sense under such conditions.

The limited supply of quality seed for local varieties can be an obstacle to farmers' continued maintenance of genetic diversity. Community genebanks provide a mechanism for storing valuable landrace germplasm in a local *ex situ* form so that farmers have more

direct access to seed when they need it. Typically small in size, community genebanks can only maintain a limited number of accessions and replicates.

The economic feasibility of community banks is also undermined by the high covariance of local crop yields, which means that many farmers in a community face similar seed deficits and surpluses. Cromwell[52] cautions that access to seed through the community system is not always egalitarian, since seed is often hoarded, or is of poor quality.

If farmers prefer to store seed on an individual basis but desire access to knowledge about the location of other seed types in surrounding villages, biodiversity registers are one low-cost, modest alternative.[53] A community biodiversity register is a record of landraces cultivated by local farmers. In addition to the names of the farmers who grow them and the place of origin, the register may include data about the agromorphological and agronomic characteristics of landraces, agroecological adaptation, and special uses.

Registers can serve as an information tool that reduces the transaction costs of locating and exchanging diverse materials, but do not solve the problem of a shortage in seed supply relative to demand. National governments, NGOs and donors have invested in local-level seed projects as a means of delivering a better range and quantity of seed types where state seed enterprises have been ineffective and the commercial seed sector has been too slow to grow or too limited in focus. Reviewing these efforts to date, Tripp concluded that few of these projects have achieved the goal of establishing viable small-scale seed production enterprises.[54] He cites as a principal obstacle the failure to recognize that seed provision requires more than multiplication. Projects internalize the costs of managing contacts involved in obtaining source seed and establishing quality control procedures, arranging for seed conditioning, and in particular, marketing the seed. When projects cease to be funded, the effectiveness of the seed enterprise falters. He argues that more must be done to support institutional growth and strengthen farmers' links with markets and institutions that are already in place.

One prerequisite for building such institutions is an understanding of existing seed exchange networks, whether formal or informal. Another is an understanding of how public systems might be adapted in order to promote the use by farmers of a more diverse range of materials. In Nepal, informal research and development (IRD) has been used to test, select, and multiply seeds.[55] A small quantity of seed of recently released and/or nearly finished varieties is distributed to a few farmers in a community to grow under their own conditions with their own practices. First practiced by Lumle Agricultural Research Centre, this approach has now been adopted by other organizations in Nepal and India for variety testing and dissemination.[56] Such approaches incur no substantive additional costs but speed the time to use of varieties since they shortcut release procedure. They are likely to enhance diversity since each farmer receiving seed exerts his or her own selection pressures.

Economic considerations in conserving crop genetic resources *ex situ*

While the economic benefits of conserving germplasm *ex situ* are difficult to estimate for the reasons explained in Section I, costs of conservation can be estimated directly by compiling the data from records kept by genebank managers.[57] One reason for focusing on costs rather than benefits is that if the costs of conserving an accession are shown to be lower than any sensible lower-bound estimate of benefits, for many decisions, it may not be necessary to undertake a challenging exercise in benefit estimation. Cost information is also crucial when a genebank manager pursues

the objective of minimizing operational costs subject to the technology and funding that is available. The methodology presented here was developed in greater detail and with empirical examples by Pardey *et al*.[58]

Economic framework

The framework of production economics provides an approach for analyzing a genebank facility and its operations. The essential notion of production economics is that outputs are produced with some combination of inputs. The institutions and technological environment that prevail at a point in time predetermine the combination of inputs, though these factors change over time. Applied to the case of a genebank, the inputs of labour, equipment, and acquired seeds are processed to produce outputs in the form of stored, viable seeds and accompanying information. Properly stored seeds and relevant information can be disseminated immediately for current use, or placed in the storage facility as options that can be exercised (repeatedly if necessary) in future years.

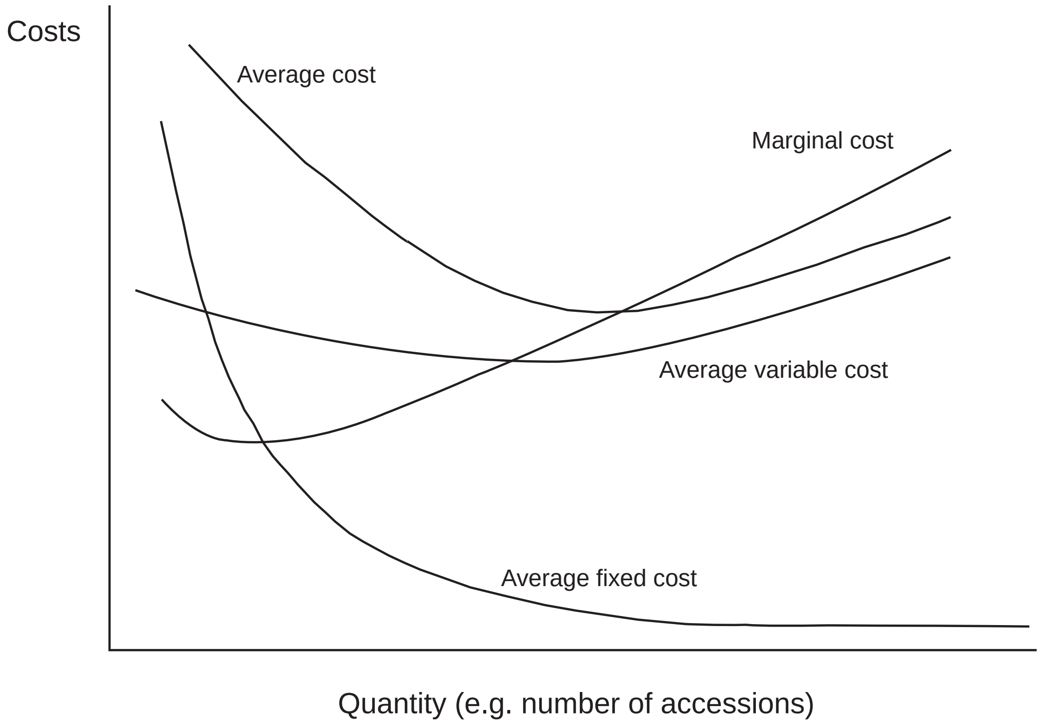
Total costs of genebank operation are broadly classified as *variable* (labour and non-labour), *capital*, and *quasi-fixed*. Quasi-fixed inputs are often called "human capital," referring to skilled labour with scientific expertise such as genebank manager and laboratory scientists. Technicians and temporary workers, or those paid on an hourly basis, are treated as variable labour inputs. Variable inputs are those that are sensitive to the size of the genebank operation, capital inputs as those that are not, and quasi-fixed inputs as a group of inputs that are neither fixed nor variable, but "lumpy." A quasi-fixed input is "lumpy" in the sense that it is a discrete, indivisible unit that cannot be adjusted easily with fluctuation in the extent of genebank operations; it is variable in that it is more easily adjusted than a capital item such as the building itself.

Costs in each class can be then summarized in terms of *average* and *marginal* costs. For example, average annual storage costs can be calculated as the total costs of storage in any year divided by the number of accessions in a storage collection. Depending on the type of inputs used in production, average cost can be represented in terms of average variable costs, average fixed costs, or the sum of both. Figure A1.3 shows the expected relationship of changes in average and marginal costs to changes in the amount of output (for example, the number of stored seeds). *Average fixed or quasi-fixed costs* generally decline monotonically as output increases—as when a given fixed cost, such as the cost of the genebank facility, is charged against a greater amount of output, such as more stored seeds. By contrast, *average variable cost* is in general U-shaped, with a minimum. As the number of accessions increases from a small size, the operation becomes more efficient and average variable cost decreases. After a certain minimum level of cost, it increases with the number of accessions due to excessive use of variable resources given fixed factors.

Marginal costs are the addition to total costs from the addition of the last unit of output. The marginal costs of storage are the *increase in total costs of storage* that are incurred when another accession is added to the collection. It is typically assumed that marginal costs eventually increase due to the law of diminishing marginal returns. The law of diminishing marginal returns reflects the proposition from classical economics, still widely recognized as empirically valid, that the physical productivity of labour declines as more labour is added to production while all other inputs are held constant.

Marginal costs are in practice difficult to estimate even with a long time series of historical data, since they depend on the size of the collection. Though the marginal cost per accession is the relevant criterion for decisions regarding lumping and splitting of accessions, theory principles are often used to "guess" marginal cost. We can assume that (1) over the

Fig. A1.3. Theoretical marginal and average cost curves.



relevant size range, marginal costs are constant, (2) curators are operating at the most efficient point possible, where average costs have reached a minimum level and equal to marginal costs, or (3) either capital or quasi-fixed inputs are utilized at a less-than-full capacity, so that marginal costs are always less than average cost. For practical purposes, the third case is generally assumed and the average costs are interpreted as upper bounds of the corresponding marginal costs.

Analyzing the costs of genebank operations

Data: Table A1.1 provides some examples of cost elements for each genebank operation by type of input. All staff with post-graduate degrees has been classified as quasi-fixed labour, though the role of staff rather than their degree or title is a more relevant criterion. Commercial rental rates often serve as estimates of the annualized cost of capital. However, if these data are unavailable, data on purchase prices and the expected service life of the item, combined with a real interest rate (nominal interest rate minus inflation rate), are all that is necessary to estimate them directly (see Appendix).

The category of information management includes all activities related to database management and publications. Software licensing fees and skilled labour for database operations constitute a large portion of information management costs. General management includes all administrative operations and other activities that are not directly attributable to specific cost categories. Electricity services, physical facilities and computers, which may be used in other operations but whose total costs cannot be disaggregated, are also classified here. Capital items that are charged on a lease-basis within the organization, such as computers or vehicles, can be treated as non-

Table A1.1. Examples of cost elements in genebank operation[a]

Operations	Non-capital			Capital
	Quasi-fixed	Labour	Non-labour	
Information management (including data analysis)	• Information manager • Data analyst	• For data entry • For equipment maintenance	• Computer supplies • Publication-related expenses • Software licences	• Servers • Computer equipment
General management	• Genebank head or genebank manager	• Secretaries • Unallocatable labour	• Office expenses • Electricity • Unallocatable expenses	• Buildings • Unallocatable equipment
Storage (medium term and long term)	• Genebank curator	• For maintaining and operating refrigeration equipment and facility	• Electricity for storage rooms	• Cold storage room • Refrigeration equipment • Storage shelves and seed container
Viability testing	• Genebank curator	• Lab technician • Worker	• Chemicals and supplies	• Lab equipment and supply
Acquisition	• Genebank curator • Scientist for seed health testing	• Lab technician • Temporary worker	• Chemicals and supplies • Seed envelope	• Lab equipment and facility
Safety-duplication	• Genebank curator	• Temporary worker	• Packing supplies • Shipping cost	
Dissemination	• Genebank curator	• Lab technician • Temporary worker	• Chemicals and supplies • Packing supplies • Shipping cost	• Equipment and facility
Regeneration	• Genebank curator • Field manager	• Field worker • Equipment technician • Temporary worker	• Chemicals and supplies for fields • Fuel for vehicle • Electricity for drying machine	• Farming land • Screenhouse • Seed dryer • Seed cleaning equipment
Characterization	• Field manager • Lab scientist	• Field worker for agronomic characterization • Lab technician for molecular characterization	• Lab chemicals and supplies	• Lab equipment and facility
Evaluation	• Field manager • Lab scientist	• Lab technician • Field worker	• Lab chemicals and supplies	• Lab equipment and facility
Pre-breeding	• Field manager • Lab scientist	• Lab technician • Field worker	• Lab chemicals and supplies	• Lab equipment and facility
Other researchers	• Genebank curator • Lab scientist	• Lab technician	• Lab chemicals and supplies	• Lab equipment and facility

[a] Pardey, P.G., B. Koo, B. D. Wright, M.E. van Dusen, B. Skovmand and S. Taba. 2001. Costing the Conservation of Genetic Resources: CIMMYT's *ex situ* maize and wheat collection. Crop Science 41:1286–1299.

labour rather than as capital costs. Management encompasses all genebank operations, and its cost should be allocated to each individual operation according to its managerial complexity and relative importance.

The major cost items in seed storage are the electricity for the refrigeration system and the capital equipment. The cost of viability testing consists of supplies and the labour of laboratory technicians. The category of acquisition includes the costs of seed health testing and seed handling. The cost of collecting from remote regions might also be included.

Both safety-duplication and dissemination involve packing and shipping seed samples, though dissemination is much more frequent and costly than duplication. Part of the costs for seed health testing (including capital items) should be allocated to the category of dissemination costs when phytosanitary certificates are required.

Regeneration is one of the most expensive activities in the genebank operation. This category includes both the fieldwork (e.g. land preparation, planting, weeding, harvesting, etc.) for seed production and the seed processing (such as drying and cleaning) for storage.

Once each cost element has been assessed and management costs have been allocated to operations, the overall composition of costs and relative magnitude of each element can be examined. The sum of all elements then represents the total annual economic cost of operating the genebank. One point that may require emphasis is that the annual economic cost estimated here may differ from the annual genebank budget in several respects. First, overhead costs may be omitted from a genebank budget but included in its economic cost. If a genebank is operated as part of a larger institution, it shares some administrative services (library, financial, and security services) with other programmes. Second, the cost of programme-wide operations such as seed health testing should be allocated according to the proportion accomplished by the genebank, but annual genebank budget may include all or none of these costs. Third, annualized capital costs (including the costs of physical facilities, land and other donated equipment) are fully represented in the economic cost, while only parts of them may be considered in an annual budget.

The average cost of each operation is calculated by dividing the total cost by the number of accessions processed. We can then compare average costs among operations or in a single operation over time, as an indicator of efficiency. Questions related to the lumping and splitting of accessions might also be addressed within this framework. Based on these figures, we can estimate the average cost of storing an accession for one year or in perpetuity. For practical purposes, as explained above, average cost can in turn be taken as an estimate of marginal cost.

The average cost of storing an accession depends critically on the status of each accession and genebank protocol. If the accession is viable and is stored in sufficient quantity, then the cost of conserving an accession for one year is very low. If the accession must be regenerated due to either low viability or low stock, then the cost includes regeneration and viability testing. The same logic applies to the cost of distributing accessions to requestors.

The magnitude of the cost of conserving an accession in perpetuity depends not only on the status of the accession but also on the time frame of each operation and the real rate of interest. Most genebanks have their protocols regarding the intervals of some operations such as viability testing, regeneration and dissemination. For example, depending on the crop, the interval of viability testing can be set at 5 or 10 years, and the regeneration interval can range from 20 to 30 years for seeds in medium-term storage and up to 100 years for those in long-term storage. The regeneration interval is further affected by the magnitude of demand for the accession—for accessions demanded with high frequency, regeneration is required

more often to replenish the stock. The pattern of requests for seed samples is difficult to predict, but it is possible to estimate the dissemination interval using historical dissemination data. The interest rate can be assumed to range from 2% to 6%.

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Appendix. In perpetuity costs of recurrent expense and annualized cost of capital.[a]

The in perpetuity cost of an operation that is performed every n^{th} years from time zero with a cost of X dollars, (in other words, the present value of an item with a service life of *n* years purchased at time zero for *X* dollars and repurchased every n^{th} year), is given by

$$C_0^n = X + \frac{X}{(1+r)^n} + \frac{X}{(1+r)^{2n}} + \ldots = X\left[1 + \frac{1}{(1+r)^n} + \frac{1}{(1+r)^{2n}} + \ldots\right]$$

(1) $$C_0^n = \left[\frac{1}{1-a^n}\right]X \quad \text{where} \quad a \equiv \frac{1}{1+r} < 1$$

For example:

The present value of a service costing *A* dollars purchased every year from time 0 is given by

(2) $$C_0^1 = \left[\frac{1}{1-a}\right]A \quad \text{where} \quad a \equiv \frac{1}{1+r} < 1$$

For example, if it costs $10 to store one accession of germplasm per year, the present value of the cost of storing that accession in perpetuity is $260 with 4% interest rate.

To calculate the annualized user cost *A* of an item costing *X* dollars purchased every *n* years, we need to solve for *A* in terms of *X* by setting

$$C_0^1 = C_0^n$$

and rearranging terms.

(3) $$A = \left[\frac{1-a}{1-a^n}\right]X \quad \text{where} \quad a \equiv \frac{1}{1+r} < 1$$

[a] Pardey, P.G., B. Koo, B. D. Wright, M.E. van Dusen, B. Skovmand, and S. Taba. 2001. Costing the Conservation of Genetic Resources: CIMMYT's *Ex situ* Maize and Wheat Collection. Crop Science 41:1286-1299.

Annex 2: Changing roles of private and public agricultural research and effects on the utilization, access to, and conservation of PGR

Changes in levels and scope of agricultural research investment by private and public institutions

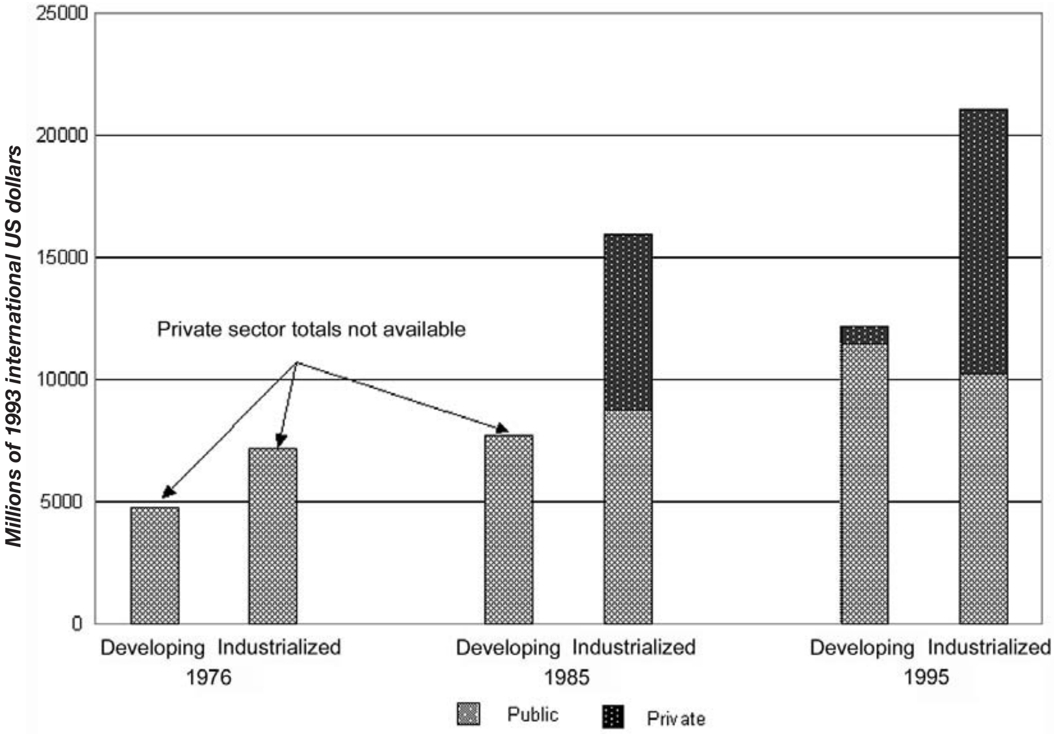
Long-term data series on private and public investment in agricultural research for both developing and developed countries are difficult to obtain.[1] Nonetheless, the available evidence suggests that since the Second World War, the public sector has financed most of the agricultural research investment in developing countries. In industrialized countries, the level of private sector investment in agricultural research has been much more comparable to the level of public sector investment, but historically the public sector totals were higher in most countries. The composition of agricultural research in the two sectors has also been different. For example, in industrialized countries, a great deal of the past private sector research has concentrated on food and related products, farm machinery and agricultural chemicals. Research on basic biological science, plant breeding or livestock improvement, or agronomy was more likely to be conducted by the public sector. In other words, public sector research has been much more farm-focused than private sector research in most rich countries, and somewhat more focused on fundamental scientific research. Private sector research has invested more heavily in farm-related than farm-focused markets.[2] As plant breeding investment is particularly relevant to issues of utilization, access, and conservation of plant genetic resources, available information on plant breeding will be discussed in greater detail below.

In more recent years, private investment in agricultural research has grown much more rapidly than public investment. Depending on the indicator used, this acceleration in private investment might be dated to about 1980, about 1970, or even earlier. As an example of this acceleration, from about 1985 to about 1995, private sector investment in agricultural research in industrialized countries grew by over 4% per year, while public sector investment only grew at about 1.5% annually (Fig. A2.1). Over some periods, private sector investment may have grown even faster in developing countries than in industrialized countries, albeit from a very low base.[3] Private sector investment in developing countries is still a fairly low proportion (just over 5% of the total) of all agricultural research expenditure in those countries[4] (Fig. A2.1).

Many factors are thought to have contributed to this rapid rate of increase in private agricultural research investment. These include new technological opportunities related to scientific advances, which have lowered the costs of doing research; changes in intellectual property regimes that have allowed private sector firms to capture more of the benefits that result from research; new institutional structures for public and private sector research collaboration and technology transfer, and increased globalization of agricultural input markets.[5]

In at least one area—agricultural biotechnology—by the late 1990s, these trends were thought to be leading to the creation of multinational "life sciences" giants, with dominant positions in pharmaceuticals, chemicals and other agricultural inputs such as seed.[6] However, by the end of the century company executives began to realize fundamental differences between pharmaceutical and agricultural industries. Coupled with consumer resistance to agricultural biotechnology in some rich countries, these differences might result in a future industry division into distinct but related categories such as large pharmaceutical firms, large chemical firms and large agricultural input firms.[7] At the moment, there are several large multinational firms, with headquarters in Europe and North America, with varying degrees of ownership of or joint ventures with agricultural input firms such as seed companies. These include Monsanto, Syngenta (formed from a merger and spinoff between Novartis and AstraZeneca[8]), Aventis (created from a

Fig. A2.1. Agricultural R&D expenditures (excluding Eastern Europe, Former Soviet Union).*



* Source: Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.; Alston, J.M., P.G. Pardey and V.H. Smith (eds.). 1999. Paying for Agricultural Productivity. Baltimore and London: published for IFPRI by The Johns Hopkins University Press.

merger of Hoechst and Rhône-Poulenc), DuPont/Pioneer and Dow Agrosciences. A somewhat smaller Mexican company, Empresas la Moderna, is nonetheless the world's leading private supplier of vegetable and fruit seeds.[9]

Differences between developing and developed countries, and among regions

Most of the monetary comparisons across countries in this chapter are made using international dollars based on purchasing power parity conversions, rather than official exchange rates. This is because comparisons using official exchange rates tend to underestimate research investments in countries with low prices and overestimate research investments in countries with high prices.[10]

General differences

Although private sector agricultural research investment has grown rapidly in both industrialized and developing countries, this paper has already noted that the level of private sector spending is much higher in industrialized countries. This probably means that the composition of total agricultural research also differs between developed and developing countries. Although research on agricultural chemicals, farm machinery and processing of agricultural

products is conducted in developing countries, relatively more developing country agricultural research has probably been conducted on plant breeding and farm-level agronomy.

Perhaps because of the greater relative importance of public sector agricultural research in developing countries, the rate of growth in public sector investment has been much higher in developing countries than in developed countries. For example, from 1976 through 1996, public sector research increased at an annual rate of 4.5% in developing countries compared with 1.9% in developed countries.[11] Over the last five years of this period, public sector research grew at a very slow rate in industrialized countries, and in some countries such as the United States probably declined.[12] Even though public sector research investments have also decelerated in developing countries, they were still growing at 3.6% annually in the first half of the 1990s.[13]

This overall increase in public agricultural research investments in developing countries conceals some marked regional differences, however. Public agricultural research spending has grown very rapidly over much of the past 25 or 30 years in China, other Asian countries and the Pacific, and West Asia and North Africa. In Latin America, public research expenditures grew very slowly over much of the 1980s, but picked up somewhat in the early 1990s. Public research investment in sub-Saharan Africa grew more slowly than in any other world region, including the developed countries, and in the early 1990s actually declined somewhat.

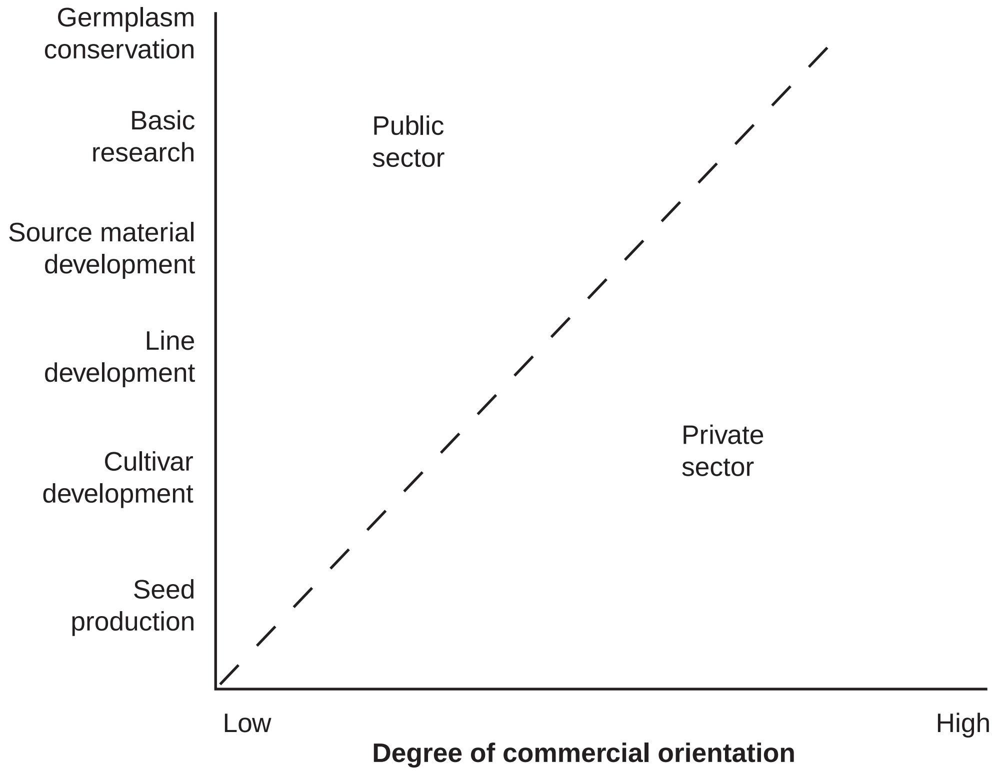
Growth rates in research investments are only one of several ways, however, that broad comparisons can be made among different countries or world regions. The levels of public research investment in developed countries imply that in the mid-1990s they were investing 2.6% of their total agricultural Gross Domestic Product (AgGDP) in public research. If both public and private totals were included, industrialized countries would have been investing 5.4% of AgGDP in research. On the other hand, developing countries were only investing about 0.6% of their total AgGDP in public research, and this percentage would increase very slightly if private research were included. Developing regions where public research investments had grown more slowly, such as Latin America and Sub-Saharan Africa, were still investing a higher percentage of their AgGDPs in research than other regions where public research expenditures had grown more rapidly, such as China and other Asian countries.[14] In fact, because China's AgGDP also grew extremely rapidly between 1976 and 1995, the percentage of AgGDP that China spent on research remained almost constant at just over 0.4%, the lowest figure for any major world region.[15]

Trends in plant breeding

As noted from the beginning, the agricultural research area with the strongest ties to the utilization of, access to, and conservation of PGR is plant breeding. Plant breeding related activities can be classified as: (1) germplasm or PGR conservation, either *ex situ* or *in situ*; (2) basic research; (3) source material development; (4) line development; (5) cultivar development, and (6) seed production and marketing.[16] These activities have alternatively been classified by Frey[17] as plant breeding research, more or less equivalent to (2) but not including basic research on plant molecular biology; germplasm enhancement, roughly equivalent to (3) and (4); and cultivar development, equivalent to (5).

In general, the private sector tends to take over more and more of these functions with increasing commercialization of agriculture, beginning with seed production and marketing (Fig. A2.2). In addition to the level of commercialization, a number of other factors have influenced the distribution of plant breeding activities between the public and private

Fig. A2.2. Natural domains for public and private plant breeding programmes.*



* Source: Morris, M.L. and B.S. Ekasingh. 2002. Plant Breeding Research in Developing Countries: What Roles for the Public and Private Sectors? In D. Byerlee and R. Echeverría (eds.) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. The World Bank, and Inter-American Development Bank, Washington, DC, USA.

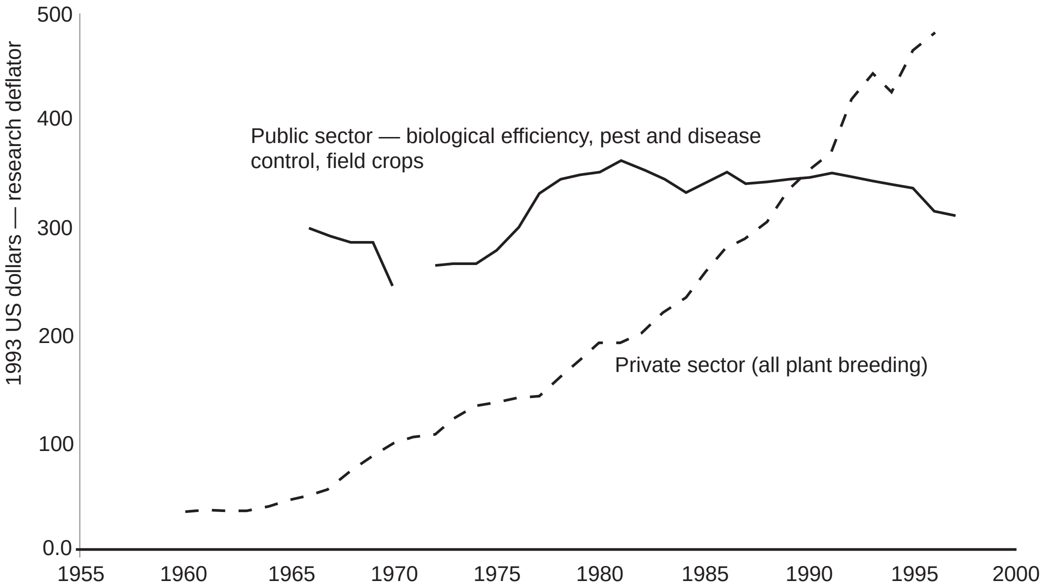
sectors across time, across crops and across political jurisdictions. A number of authors[18] have attempted to outline the factors determining the type and level of private sector plant breeding investment and thus the balance of investment between private and public sectors. These include the cost of research innovation; market structure factors such as the perceived size of a seed market and the balance of farm size between large and small; industrial organization of the seed industry, or the relative size of different seed companies; and the ability to appropriate the returns to research, through some combination of technical means and intellectual property regime.[19]

In many industrialized countries, public and private plant breeding sectors have developed and coexisted for more than a century. Over the course of the 20th century, however, the general trend in these countries has been for the private sector to become increasingly active in plant breeding. Available data suggest that over the last 30 or 40 years, trends in private and public plant breeding investment in industrialized countries have followed trends in total agricultural research. In the USA, for example, plant breeding as a percentage of total private agricultural research rose from 3% in 1960 to 13% by the mid-1990s. Though

this might still not seem large, it was accompanied by declines in the percentage of private research devoted to machinery (36% to 13%) and food products and processing (45% to 29%).[20] Looking at available data in another way, private sector plant breeding expenditures in the USA have increased more than tenfold from 1960 to the mid-1990s, for an annual rate of growth averaging well over 7%. In contrast, public sector plant breeding expenditures rose more slowly until the early 1980s, after which they stagnated. They may have even fallen in recent years. In the USA, private sector plant breeding expenditures have surpassed public sector expenditures since the late 1980s (Fig. A2.3). In a few developed country cases where plant breeding expenditures for a given crop, both public and private, can be calculated as a percentage of the value of production, these percentages have tended to range between 0.3 and 0.9%.[21]

At the level of cultivar development and release, most discussions of plant breeding in industrialized countries have focused on the ability of private firms to appropriate a greater proportion of the returns to research. Private and social returns from plant breeding may diverge in cases where firms are unable to profit from the benefits of their research. For example, in the past plant breeding for self-pollinating crops such as wheat, for which farmers can replant seed saved from the previous harvest, was often done by the public sector because private sector firms could not charge enough for seed to make plant breeding profitable. On the other hand open-pollinating crops like maize have permitted the development of commercial

Fig. A2.3. Real public and private sector expenditures on plant breeding, USA, research deflator.*



* Source: Heisey, P.W., C.S. Srinivasan and C. Thirtle. 2001. Public Sector Plant Breeding in a Privatizing World. Agricultural Information Bulletin No. 772. Economic Research Service, US Department of Agriculture, Washington, DC.

hybrids, for example as early as the 1930s in the USA. These crops permit private firms to protect some of their research investment through knowledge of the inbred combination used to produce the hybrid, or knowledge of the composition of the inbred lines themselves. Farmers who replant seed of hybrid maize are faced with a marked deterioration of performance. Another consideration in appropriability of research returns has been intellectual property protection, for example through plant variety protection laws and, more recently in the USA, through the use of utility patents.

Data on the origins of crop varieties planted in industrialized countries confirm the importance of hybrid crops and intellectual property protection in determining private sector plant breeding investment in industrialized countries, as well as some of the other factors identified above. The empirical data also bring to light some additional factors that were not previously identified. As expected, nearly all maize hybrids planted in developed countries today originate in the private sector, although as late as the 1970s in the USA, a substantial proportion of the inbred lines used by private seed companies originated in the public sector. Today nearly all maize inbreds, as well as the final commercial hybrids, are produced by the private sector. In the USA plant breeding for cotton, a self-pollinating crop, began to shift from the public to the private sector at least 40 years ago, and today the private sector dominates. The private sector is also now much more prominent than the public sector in plant breeding for soyabeans in the USA and canola in Canada, although this shift has occurred more recently, in the past 20 or 30 years. Many wheat varieties in Europe, particularly northern Europe, come from the private sector, as do wheat varieties in the Eastern USA, where wheat is primarily a rotation crop. On the other hand wheat breeding in Canada, Australia and the Great Plains and Pacific Northwest of the USA is still predominantly in the public sector. Some of the additional factors uncovered by the empirical record include technical factors other than hybridization (e.g. the need to gin and de-lint cotton seed), market factors (e.g. crops that are grown in rotation with other crops that already have strong private sector plant breeding programmes, such as soyabeans or wheat in the Eastern USA) and early research sponsorship by the product output industry (e.g. Canadian canola, and perhaps soyabeans as well).[22]

Plant breeding research in most developing countries is still dominated by the public sector for two reasons: the continued large significance of agriculture in the economies of many developing countries, and the limited market opportunities for commercial seed sales to small farmers who may be subsistence oriented. However, plant breeding in developing countries is also being affected by the commercialization of agriculture, the privatization of national seed industries, the strengthening of intellectual property rights, and the erosion of public research capacity.[23] In most cases, monetary estimates of plant breeding research investments in developing countries are not available, but some indicators do allow comparisons across crops, regions and institutions.

By the late 1990s, although 38% of the maize area in developing countries was still planted to farm-saved seed (53% of the maize area in non-temperate developing countries), total private sector investment in maize breeding in these countries was greater than public sector maize breeding investment. Just under one-half of the total came from multinational companies, and another one-sixth from private, nationally based companies. Overall, only about a third of the maize breeding investment was in the public sector. These overall trends were mirrored in Latin America, the region with the largest maize breeding expenditures, and in East, South and Southeast Asia. Only in Eastern and Southern Africa did public sector maize breeding still

dominate, accounting for just over 70% of the total.[24] On the other hand, public sector wheat breeding continues to be of overwhelming importance in developing countries. Private sector wheat breeding programmes are only found in the Southern Cone of South America and Southern Africa, and less than 4% of developing country wheat area is planted to private sector wheat varieties, mainly in Argentina, Brazil and South Africa.[25] Adoption data on high-yielding rice varieties also suggests that public sector varieties dominate in rice as well.[26] Hybrid rice is quite widely grown in China, but all the cultivars grown have been developed by the public sector. Private sector soyabean varieties may be important in Argentina and Brazil, but data to state this definitively are not presently available.

In addition to plant breeding investments by national public sector agricultural research programmes, and national and multinational private sector companies, international agricultural research centres (IARCs) have played an important role in international plant breeding efforts.[27] They have helped develop improved germplasm, played a role in the conservation of genetic resources, and helped to strengthen the breeding capacity of national agricultural research systems (NARS) through training activities.[28] The large impact they have had (for example over 75% of the developing country spring bread wheat area worldwide and 95% of the irrigated lowland rice area in Asia are planted to IARC-derived modern varieties) has been achieved despite the relatively small size of IARC breeding programmes. Accurate estimates of the exact amount of IARC expenditures devoted to plant breeding depend on the assumptions made, but by the late 1990s this may have been in the range of 150 million 1993 US dollars annually, using a broad definition of plant breeding. This is down from a high point of over 200 million 1993 US dollars annually in the late 1980s (Fig. A2.4). The TAC review of CGIAR plant breeding programmes, using a narrower definition, calculated a total of about 83 million dollars (1993) invested in plant breeding and biotechnology in 1999.[29]

The reader will have noted that most of the discussion of plant breeding investments by both public and private sectors in both developing and developed countries has been focused on major field crops, for which most of the data are available. It is presumed that plant breeding for minor crops, to the extent that it is done at all, is more likely to be conducted by the public than the private sector, although this is a matter of conjecture. First, there is the matter of definition of minor crops. The definition may vary somewhat from country to country. Minor crops may consist of field crops that are grown in a rather limited area or for niche markets, fruits and vegetables, or some kinds of forage crop.[30] The empirical record for the USA, where some data based on number of breeders are available, is mixed. The preponderance of vegetable and melon breeding appears to be done by the private sector, as is a greater proportion of forage legume breeding. Breeding for temperate fruit and nut crops, or forage grasses, on the other hand, is more likely to be conducted by the public sector.[31]

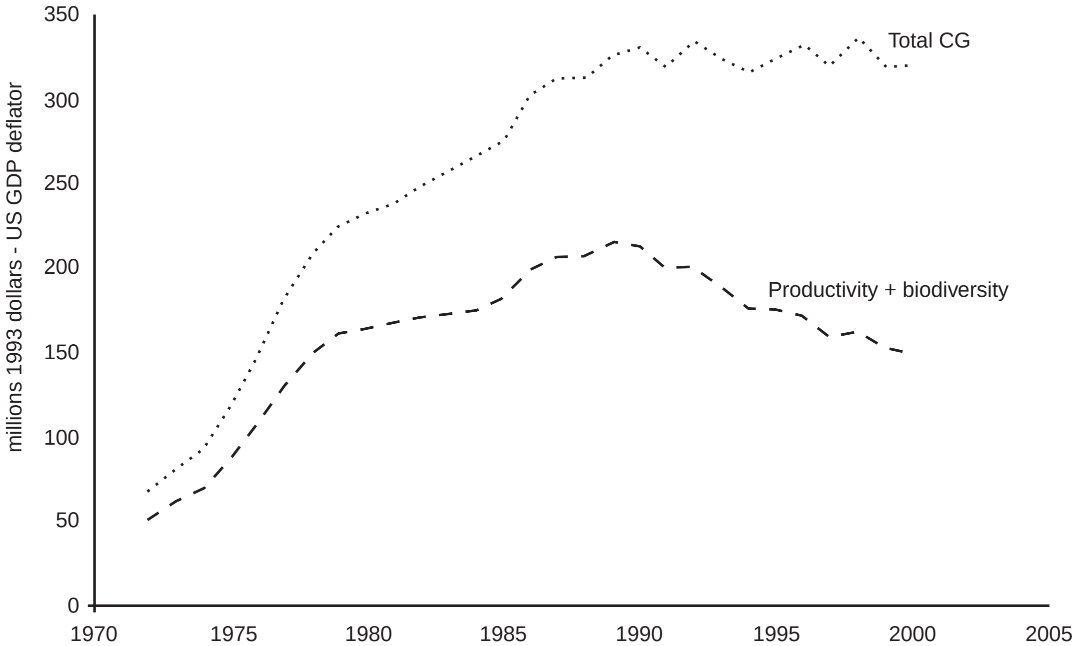
Implications for the types of agricultural technology that result, and how PGR are utilized

The changing institutional structure of agricultural and plant breeding research has several implications for the use of PGR. Two of the most important issues are the types of technologies that are developed and the ways in which access to PGR is maintained or altered.

Implications for technology development

Morris and Ekasingh[32] summarize the preceding discussion by categorizing crops according to current incentives for private

Fig. A2.4. Total CGIAR investment and approximate CGIAR plant breeding investment.*



* Source: Consultative Group on International Agricultural Research (CGIAR). Various years. Annual Reports.; Alston, J.M., P.G. Pardey and V.H. Smith (eds.). 1999. Paying for Agricultural Productivity. Baltimore and London: published for IFPRI by The Johns Hopkins University Press.

sector investment in plant breeding research. They place crops on a two-dimensional grid, defined by whether the benefits from plant breeding are non-appropriable or appropriable, and whether producers are non-commercial or commercial. Of course, in reality both dimensions are continuous rather than discrete, but the resulting definitions are useful. In Morris and Ekasingh's scheme, "non-appropriable" crops grown by non-commercial producers would include both self- and open-pollinating crops grown for home consumption in developing countries, as well as vegetatively propagated crops in these countries. "Appropriable" crops grown by non-commercial producers consist of hybrid crops grown for home consumption in developing countries. "Non-appropriable" crops grown by commercial producers would include self-pollinating crops grown for market in developing countries and most self-pollinating crops grown in developed countries. "Appropriable" crops grown by commercial producers would include hybrid crops and cotton grown for market in developing countries, and also hybrids and cotton in developed countries. Incentives for private sector plant breeding research are highest for "appropriable" crops grown by commercial producers, lowest for "non-appropriable" crops grown by non-commercial producers, and intermediate for the other two categories.

As the empirical survey has indicated, any particular crop–country–time combination will have to be examined in more detail to

determine the balance of private and public research more precisely. Furthermore, there is another factor related to but not identical with private sector plant breeding investment that will also help to determine the types of technology that result, and the ways PGR are utilized. This is the breeding history of the crop. Breeding history is partially determined by commercialization and appropriability factors, but it is also influenced by the total size of the market and the nature of the breeding process. For example, wheat and rice are similar self-pollinating crops, but wheat has a longer breeding history because it is grown in both temperate and cool-season tropical environments around the world, while rice is more concentrated in hot environments, particularly in Asia. Furthermore, a greater proportion of the wheat crop is probably grown for market. Even focusing on developed countries, crops like wheat and maize would have a broader history of breeding effort than crops like oats or rye, because of the relative market sizes. Wheat also has a somewhat longer breeding history than maize, because the pedigree breeding used for wheat was somewhat simpler to develop than the multiplicity of breeding possibilities found for maize, especially before the details of commercial hybrid production were worked out. And of course crops that reproduce through seed nearly always have a more intensive breeding history than crops that are vegetatively propagated.

The degree of private sector involvement in plant breeding may have several implications for the type of technology developed. Perhaps most obviously, the private sector is likely to give more emphasis than the public sector to the development of commercial hybrids in crops that have not already been successfully hybridized for commercial purposes.[33]

But there are other areas in which private and public sector plant breeding may take somewhat different approaches. Nutritional characteristics or environmental suitability of plant varieties may take the form of "impure public goods." This means that these attributes meet some, if not all, of the definition of what economists call "public goods". The basic economic argument in the case of a public good is that private individuals taking into account only their own preferences will produce less of the public good than would bring the greatest social benefits.[34] Disease resistance in plants is a particular example of an impure public good.[35] Public sector research programmes and policies are likely to devote relatively more effort to diagnosing needs in the areas of nutrition and environmental suitability of plant varieties, and searching for genetic and management means to achieve these ends.

This is not to say that private breeding research will neglect important areas like disease research. Any private company that wishes to stay in business will attempt to supply farmers with varieties having good disease resistance, if that is an important consideration in the target area. However in research and seed systems with a long history of development, opportunities for complementary research may develop. The public sector may take the lead in doing research on basic mechanisms of disease resistance and finding a wide variety of possible sources of that resistance. The private sector may devote more effort to developing readily identifiable, proprietary genetic mechanisms for resistance such as the *Bt* incorporated into plants through genetic engineering.

Implications for access

The main avenue through which growing privatization of plant breeding has affected access to PGR has been through the increasing emphasis on proprietary technology and the protection of crop varieties or individual genetic constructs through intellectual property institutions. The traditional view of PGR was that they were "the common heritage of mankind", and for many crops and breeding

institution the maintained ideal was "the free exchange of germplasm". Obviously there were different degrees to which this ideal obtained in practice. Private firms in advanced hybrid maize seed industries tend to rely almost completely on their own germplasm, even though many years ago this germplasm was obtained from public sources, and, ultimately, from farmers.

Beginning in the 1980s, academic researchers and agricultural activists motivated by increasing proprietary control of PGR began to criticize the growing application of intellectual property rights to these genetic resources. Their arguments focused on the role of farmers, particularly in the developing world, in developing the original crop landraces that have been the basis of all subsequent breeding. IPR, in some views, facilitated the exploitation of gene-rich farmers in developing countries by multinational corporations. Although much of the argument focused on "farmers' rights", rather than the rights of countries, increasingly the ownership of PGR was seen as a matter of national sovereignty. Debates over PGR entered the international policy realm through trade negotiations, the Convention on Biological Diversity, the Cartagena Protocol on Biosafety, and, most recently, the International Treaty on Plant Genetic Resources for Food and Agriculture.[36]

As a result of both the changed research environment and the increasing body of international undertakings that have effects on access to PGR, exchange of PGR has for some time come under increasing restrictions. Even institutions such as the US National Plant Germplasm System (NPGS), the world's largest national genebank and largest international distributor of PGR, and the CGIAR genebanks and breeding programmes either use or are moving toward the use of material transfer agreements (MTAs) in germplasm distribution.[37] Although these may only have the intent of preventing further application of intellectual property protection to the PGR involved, they do increase the transaction costs of PGR distribution and exchange, and thus have the effect of slowing access. These transaction costs include the costs of tracking the movement and use of PGR.

At least two important factors will interact to determine the future effects of increasing privatization and intellectual property protection on access to PGR. The first will be the continually evolving national and international institutional environment concerning the application of intellectual property laws to living material. Although the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement of the World Trade Organization (WTO) requires all members to apply some form of intellectual property protection to plants, there are still strong differences of opinion over the appropriate types and levels of such protection. Recent negotiations over the International Treaty on Plant Genetic Resources were marked by the refusal of groups of countries to include some crops in a negotiated multilateral system of materials from genebanks. The negotiations also featured disagreements over language defining restrictions on intellectual property protection on germplasm based on materials drawn from the proposed multilateral system.[38]

The second factor that will influence the future relationship between IPR and access to PGR will be evolving science. Currently, some of the most notorious international disputes over patenting of plant genetic materials have involved crops with relatively short breeding histories (e.g. beans, basmati rice). In these situations, patent protection may be granted to material that appears little different from germplasm grown for generations by farmers in developing countries. In the case of crops with longer breeding histories, there are instances of complicated patterns of materials transfer through a number of countries and institutions and eventual patenting (e.g. the XA 21 gene for bacterial blight resistance, which originally came from rice). To date,

there have been few cases of "vertical" disputes—disputes over the contributions made by different actors in the breeding process—over ownership to PGR used in crops with a long breeding history.[39] This is perhaps because breeders for these crops tend to work with elite materials, and the chance of finding a single highly profitable allele that is easily incorporated into these elite materials is small. New molecular methods, however, may result in the discovery of useful alleles in landraces or wild relatives, even those that have been relegated to the sidelines because of their perceived lack of useful genetic material.[40] On the one hand, hope of exploitation of the perceived economic value of these alleles may lead to further restrictions on the exchange of PGR. On the other hand, advanced molecular methods may lead to greater recognition of the genetic combinations necessary to achieve desired results, and thus to fewer hold-ups based on a single gene.

Implications for the conservation of PGR

The economics literature on the valuation of genetic resources at any stage in the process from discovery to utilization in a commerical product is fraught with controversy, not least because of differing assumptions used. Nonetheless, there is considerable consensus on several areas. First, both *in situ* and *ex situ* conservation of PGR are highly valuable activities, with positive social benefits. Second, the further back in the breeding process one goes, the fewer private incentives there are. This may be because of differences between social and private discount rates and risk preferences. Thus, conservation of PGR is in large part a public sector activity, even if large private firms maintain their own collections of primarily elite breeding materials. Even private sector organizations such as the American Seed Trade Association argue for the fundamentally public nature of PGR conservation.[41]

There are several practical problems, however, in maintaining support for national and international public sector PGR conservation activities. First is the relatively stagnant level of public sector research resources noted above. In rich countries there have been calls for more resources, reorganization, and more extensive characterization and database management activities within national plant genetic resource systems. However, political support for public agricultural research systems has been built in part on the production of visible, "downstream" results, thus making it difficult to place investment in PGR conservation high on the political agenda. Furthermore, a very large component of international PGR conservation will be in developing countries, and it will need to be supported by the international community.

A related problem will be working out the mechanisms of support to PGR conservation. The International Treaty on Plant Genetic Resources has proposed one such mechanism, in which commercial use of genebank materials will provide royalties to support conservation. However, as we have seen not all potentially important crops have been included in this treaty; the USA, with the largest national genebank, abstained from the treaty, although it is expected to abide by its provisions; details about tracking the flows of genetic resources, the levels of royalties to be paid, and the distribution of those royalties have not yet been worked out; and the annual royalties are not realistically expected to be more than a few million dollars, and that only beginning some years from now.[42] Alternative mechanisms might involve other private support for PGR conservation, based not on royalties but on direct payments unrelated to the exact PGR used in breeding. Again, such agreements would depend on the development of mutual trust and careful protocols. The LAMP (Latin American Maize Project) and subsequent GEM (Genetic Enhancement of Maize) project might provide

one model for some possible private support to PGR conservation activities.[43]

Such measures, however, are likely to prove most successful for crops for which there is some commercial interest. Shortages of funds for PGR conservation are likely to be particularly acute for crops for which there have also been shortages of funds for crop improvement, for example important food crops such as cassava. PGR conservation for these crops is likely to continue to be funded almost entirely with public sector resources. Intermediate between crops grown fairly widely on a commercial scale and crops with little commercial interest are crops that might reach somewhat more specialized markets. These crops are most likely to be marked by IPR disputes over PGR, but also relatively little private interest in PGR conservation.

Over the long run, creating a more optimal system of PGR conservation will require both greater resources and trust of public and private sectors in both the developing and developed worlds, as well as careful attention to building appropriate institutions. Privatization of agricultural research is unlikely to be reversed, but PGR conservation is a research area for which there are strong economic arguments for increasing public investment.

Endnotes

1 Throughout this paper, no information will be presented for Eastern Europe and the Former Soviet Union, countries for which data are particularly difficult to find.

2 Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.

3 Pray, C.E. and D. Umali-Deininger. 1998. The Private Sector in Agricultural Research Systems: Will It Fill the Gap? World Development 26:1127-1148.

4 Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.

5 Shoemaker, R. (ed.), with contributions from J. Harwood, K. Day-Rubenstein, T. Dunahay, P. Heisey, L. Hoffman, C. Klotz-Ingram, W. Lin, L. Mitchell, W. McBride, and J. Fernandez-Cornejo. 2001. Economic Issues in Agricultural Biotechnology. Agricultural Information Bulletin No. 762. Economic Research Service, U.S. Department of Agriculture, Washington, DC.

6 Fertilizers and crop protection inputs such as herbicides straddle the boundary between chemicals and agricultural inputs. [Enríquez, J. 1998. Genomics and the World's Economy. Science 281 (August 14, 1998):925-926].

7 Wright, B. 2000. IPRs in Biotechnology: Agricultural Applications. Presentation at the symposium, Intellectual Property Rights: How Far Should They Be Extended? 3 February 2000, Board on Science, Technology, and Economic Policy, National Academy of Sciences, Washington, DC.

8 Novartis and AstraZeneca were themselves products of mergers in the mid- to late 1990s.

9 Empresas la Moderna also has a growing investment in biotechnology.

10 Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.

11 Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.

12 USDA Economic Research Service. 2000. Agricultural Resource and Environmental Indicators, 2000. Washington, DC: Resource Economics Division, Economic Research Service, USDA. http://www.ers.usda.gov/Emphases/Harmony/issues/arei2000/

13 Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.

14 Agricultural research as a percentage of AgGDP did decline in sub-Saharan Africa between 1985 and 1995.

15 Pardey, P.G. and N.M. Beintema. 2001. Slow Magic: Agricultural R&D a Century After Mendel. IFPRI Food Policy Report. IFPRI, Washington, DC.

16 Morris, M.L. and B.S. Ekasingh. Plant Breeding Research in Developing Countries: What Roles for the Public and Private Sectors? In D. Byerlee and R. Echeverría (eds.) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI, Wallingford, UK. (In press)

17 Frey, K.J. 1996. National Plant Breeding Study-1. Human and Financial Resources Devoted to Plant Breeding Research and Development in the United States in 1994. Special Report 98, Iowa Agriculture and Home Economics Experiment Station. Iowa State University, Ames.

18 Griliches, Z. 1957. Hybrid Corn: An Exploration in the Economics of Technological Change. Econometrica 25:501-522.

Rusike, J. 1995. An Institutional Analysis of the Maize Seed Industry in Southern Africa. Ph.D. dissertation. Michigan State University, East Lansing, Michigan.
Morris, M.L. (ed.) 1998. Maize Seed Industries in Developing Countries. Lynne Rienner Publishers, Boulder, Colorado.
Heisey, P.W., M.L. Morris, D. Byerlee and M.A. López-Pereira. 1998. Economics of Hybrid Maize Adoption. *In* M.L. Morris (ed.), Maize Seed Industries in Developing Countries. Lynne Rienner Publishers, Boulder, Colorado.
Heisey, P.W., C.S. Srinivasan and C. Thirtle. 2001. Public Sector Plant Breeding in a Privatizing World. Agricultural Information Bulletin No. 772. Economic Research Service, US Department of Agriculture, Washington, DC.
Morris, M.L. and B.S. Ekasingh. Plant Breeding Research in Developing Countries: What Roles for the Public and Private Sectors? *In* D. Byerlee and R. Echeverría (eds.) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI, Wallingford, UK. (In press)

[19] Heisey, P.W., C.S. Srinivasan and C. Thirtle. 2001. Public Sector Plant Breeding in a Privatizing World. Agricultural Information Bulletin No. 772. Economic Research Service, U.S. Department of Agriculture, Washington, DC.

[20] The other component of private agricultural research in the USA that demonstrated large gains was agricultural chemicals, which rose from 13% to 37% of the total between 1960 and the mid-1990s. [USDA Economic Research Service. 2000. Agricultural Resource and Environmental Indicators, 2000. Washington, DC: Resource Economics Division, Economic Research Service, USDA. http://www.ers.usda.gov/Emphases/Harmony/issues/arei2000/]

[21] The notable exception is canola in Canada. In recent years, over 4% of the annual value of Canadian canola production has been invested in canola improvement research. [Heisey, P.W., C.S. Srinivasan and C. Thirtle. 2001. Public Sector Plant Breeding in a Privatizing World. Agricultural Information Bulletin No. 772. Economic Research Service, US Department of Agriculture, Washington, DC.]

[22] Heisey, P.W., C.S. Srinivasan and C. Thirtle. 2001. Public Sector Plant Breeding in a Privatizing World. Agricultural Information Bulletin No. 772. Economic Research Service, U.S. Department of Agriculture, Washington, DC.

[23] Morris, M.L. and B.S. Ekasingh. Plant Breeding Research in Developing Countries: What Roles for the Public and Private Sectors? In D. Byerlee and R. Echeverría (eds.) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI, Wallingford, UK. (In press)

[24] Morris, M.L. Impacts of International Maize Breeding Research in Developing Countries, 1966-98. CIMMYT, Mexico, DF. (in press)

[25] Heisey, P.W., M.A. Lantican and H.J. Dubin. Assessing the Benefits of International Wheat Breeding Research in the Developing World: The Global Wheat Impacts Study, 1966-1997. CIMMYT, Mexico, DF.

[26] Morris, M.L. and B.S. Ekasingh. Plant Breeding Research in Developing Countries: What Roles for the Public and Private Sectors? In D. Byerlee and R. Echeverría (eds.) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI, Wallingford, UK. (In press)

[27] Evenson, R. and D. Gollin (eds). 2001. Crop Variety Improvement and its Effect on Productivity: The Impact of International Agricultural Research. CABI, Wallingford, U.K.

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[29] Ibid.

[30] For some U.S. definitions, see Frey, K.J. 1997. National Plant Breeding Study—II. National Plan for Promoting Breeding Programs for Minor Crops in the U.S. Special Report 100, Iowa Agriculture and Home Economics Experiment Station. Iowa State University, Ames.

[31] Frey, K.J. 1996. National Plant Breeding Study—1. Human and Financial Resources Devoted to Plant Breeding Research and Development in the United States in 1994. Special Report 98, Iowa Agriculture and Home Economics Experiment Station. Iowa State University, Ames.

[32] Morris, M.L. and B.S. Ekasingh. Plant Breeding Research in Developing Countries: What Roles for the Public and Private Sectors? In D. Byerlee and R. Echeverría (eds.) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI, Wallingford, UK. (In press)

[33] The waxing and waning of enthusiasm for commercial wheat hybrids is instructive. See, e.g.: Knudson, M.K. and V.W. Ruttan. 1988. Research and Development of a Biological Innovation:

Hybrid Wheat. Food Research Institute Studies 21(1):45-68; Lucken, K.A. 1987. Hybrid Wheat. In E.G. Heyne (ed.), Wheat and Wheat Improvement. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, Wisconsin; Jordaan, J.P. 1996. Hybrid Wheat: Advances and Challenges. In M.P. Reynolds, S. Rajaram, and A. McNab (eds.), Increasing Yield Potential in Wheat: Breaking the Barriers. CIMMYT, Mexico, D.F.; Pickett, A.A. and N.W. Galwey. 1997. A Further Evaluation of Hybrid Wheat. Plant Varieties and Seeds 10:15-32.

[34] Alternatively the result of private individuals acting in isolation will be too much production of a "public bad" such as pollution.

[35] Heisey, P.W., C.S. Srinivasan and C. Thirtle. 2001. Public Sector Plant Breeding in a Privatizing World. Agricultural Information Bulletin No. 772. Economic Research Service, US Department of Agriculture, Washington, DC.

[36] Charles, D. 2001. Seeds of Discontent. Science 294 (October 26, 2001):772-775.
Van Dusen, E. 2001. The International Treaty on Plant Genetic Resources for Food and Agriculture. Presentation at USDA Economic Research Service, December 11, 2001.

[37] Smale, M., K. Day-Rubenstein, A. Zohrabian and T. Hodgkin. 2001. The Demand for Crop Genetic Resources: International Use of the US National Plant Germplasm System. EPTD Discussion Paper No. 82. Environment and Production Technology Division (EPTD), IFPRI, Washington, DC.

[38] As an example of the complexities involved, at Treaty negotiations, US NPGS representatives were willing to accept language eventually ratified, but the USA abstained from approving the treaty because industry representatives disagreed with any restrictions on patenting that would contradict US law. It is far from clear, however, that even within the USA, the country that has gone further than any other in applying patent protection to plants, the final determination of the boundaries of patent law as applied to living material has been reached.
Charles, D. 2001. Seeds of Discontent. Science 294 (October 26, 2001):772-775;
Van Dusen, E. 2001. The International Treaty on Plant Genetic Resources for Food and Agriculture. Presentation at USDA Economic Research Service, December 11, 2001.]

[39] Disputes instead tend to be "horizontal"—for example, between two hybrid maize seed companies.

[40] Tanksley, S.D. and S.R. McCouch. 1997. Seed Banks and Molecular Maps: Unlocking Genetic Potential from the Wild. Science 277 (22 August, 1997):1063-1066.

[41] American Seed Trade Association (ASTA). 1994. ASTA Corn and Sorghum Basic Research Committee: Recommendations for Public Corn and Sorghum Research. American Seed Trade Association, Washington, DC.

[42] Charles, D. 2001. Seeds of Discontent. Science 294 (October 26, 2001):772-775.

[43] Knudson, M.K. 2000. The Research Consortium Model for Agricultural Research. In K.O. Fuglie and D.E. Schimmelpfennig (eds.), Public-Private Collaboration in Agricultural Research: New Institutional Arrangements and Economic Implications. Iowa State University Press, Ames, Iowa.

Acronyms and abbreviations

ABS	Access and Benefit-Sharing
AgGDP	agricultural gross domestic product
AIA	Advanced Informed Agreement
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
COGENT	Coconut Genetic Resources Network
COP	Conference of the Parties
DSU	Dispute Settlement Understanding
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FTO	freedom to operate
GATT	General Agreement on Tariffs and Trade
GEF	Global Environment Facility
GEM	Genetic Enhancement of Maize
GI	geographical indicators
GMO	genetically modified organism
GR	genetic resources
IARC	International Agricultural Research Centre
IARC	International Agricultural Research Centre
IDRC	International Development Research Centre
IP	intellectual property
IPGRI	International Plant Genetic Resources Institute
IPPC	International Plant Protection Convention
IPR	intellectual property right(s)
IRD	Informal Research and Development
IT	International Treaty
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IU	International Undertaking (on Plant Genetic Resources)
LAMP	Latin American Maize Project
LMO	living modified organism
LMOs—FFP	living modified organisms—foods for feed or processing
MTA	material transfer agreement
NARS	National Agricultural Research System
NGO	non-governmental organization
NPGS	National Plant Germplasm System
PBR	Plant Breeders' Rights
PGR	plant genetic resources
PGRFA	plant genetic resources for food and agriculture
PIC	Prior Informed Consent
PVP	plant variety protection
R&D	research and development
RAFI	Rural Advancement Foundation International
SADC	Southern African Development Community
SPS	Sanitary and Phytosanitary Agreement
SPS	Syndicat des producteurs de semences sélectionnées
TAC	Technical Advisory Committee
TBT	Technical Barriers to Trade

TOR	Terms of Reference
TRIPS	Trade Related Aspects of Intellectual Property Rights
UNEP	United Nations Environment Programme
UPOV	International Union for the Protection of New Varieties of Plants (Union pour la protection des obtentions végétales)
WIPO	World Intellectual Property Rights Organization
WTO	World Trade Organization

IPGRI

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