Bioversity International

A road map for implementing the multilateral system of access and benefit-sharing in India

Edited by: M. Halewood, P. Brahmi, P.N. Mathur and K.C. Bansal

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Bioversity International is a research-for-development organization working with partners worldwide to use and conserve agricultural and forest biodiversity for improved livelihoods, nutrition, sustainability and productive and resilient ecosystems. Bioversity International is working towards a world in which smallholder farming communities in developing countries of Africa, Asia and the Americas are thriving and sustainable. Bioversity International focuses on rain-fed farming systems, primarily managed by smallholder farmers, in areas where large-scale agriculture is not a viable option. Its research influences policy decisions and investment in agricultural research, from the local level to the global level.

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The **National Bureau of Plant Genetic Resources** (NBPGR) in New Delhi functions under the administrative control of the Crop Science Division of ICAR. The mandate of the NBPGR is to act as a nodal institute at national level for the acquisition and management of indigenous and exotic plant genetic resources for food and agriculture, and to carry out related research and human resource development, for the sustainable growth of agriculture. The Bureau draws guidelines from the Crop Science Division of ICAR, the Bureau's Management Committee, Research Advisory Committee and Germplasm Advisory Committees. The Bureau has five divisions, two units, three cells, an experimental farm at its headquarters in New Delhi, and ten regional/base stations located in different phyto-geographical zones of India. Besides this, an All India Coordinated Research Project on Under-utilized Crops is also located at the Bureau. http://www.nbpgr.ernet.in/

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Bioversity Headquarters
Via dei Tre Denari 472/a
00057 Maccarese (Fiumicino) Rome, Italy
Tel: (39-06) 61181
Fax: (39-06) 61979661
Email: bioversity@cgiar.org

Contents

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The development of these papers and the workshop were guided by a coordinating team, comprised of Dr Michael Halewood, Policy Theme Leader, Bioversity International; Dr Prem Mathur, South Asia Coordinator, Bioversity International; Dr S. Ayyappan, Director General, ICAR; Dr K.C. Bansal, Director, National Bureau of Plant Genetic Resources (NBPGR); Dr P.L. Gautam, Chairperson, PPV&FR Authority; and Dr Balakrishna Pisupati, Chairman, National Biodiversity Authority (NBA) of India.

The coordinating team expresses its gratitude to the authors of the papers, the participants at the workshop, and all of the people in India, and around the world, who conserve and sustainably use plant genetic resources for food and agriculture.

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Many thanks to Elizabeth O'Keeffe for her efforts editing the papers.

Foreword

In 2001, the international community took an extremely important step forwards, when the Council of the Food and Agriculture Organization of the United Nations (FAO) adopted the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The ITPGRFA provides a forum for countries to develop shared approaches to conserving and sustainably using genetic resources, and sharing the benefits that can be derived from them. Most importantly, the ITPGRFA creates the multilateral system of access and benefit-sharing (multilateral system). Through the multilateral system, plant breeders, researchers, farmers, gardeners and other actors in ITPGRFA member countries (including India), have the benefit of facilitated access to the genetic resources of 64 important crops and forages in other member countries, as well as the *ex situ* collections hosted by CGIAR Centres. The international community has agreed on the benefit-sharing formula to help redistribute some of the benefits associated with that use. In recent years, the increasing occurrence of dramatic climatic events has demonstrated that countries will become more and more dependent on the genetic diversity they can access from each other through the multilateral system, as they search for the means to mitigate and adapt to climate change. Given India's wealth in crop genetic diversity, the strength of her agricultural research infrastructure, and her historic record as both an international provider and recipient of plant genetic resources, India has the opportunity to move the international community forwards by implementing the multilateral system through efficient, clear and inclusive mechanisms. Bioversity International is pleased to be able to work with the Indian Council of Agricultural Research (ICAR), the National Bureau of Plant Genetic Resources (NBPGR) and a range of stakeholders in India, as they explore ways forwards in this regard. In this larger context, we are also very pleased to co-publish this book with the NBPGR and ICAR.

Ms M. Ann Tutwiler
Director General, Bioversity International

Foreword

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) provides a legal framework for international cooperation in the conservation, sustainable use and sharing of benefits associated with all plant genetic resources for food and agriculture. India ratified the ITPGRFA in 2003. It has been widely acknowledged that considerably more awareness about the ITPGRFA and its multilateral system of access and benefit-sharing (multilateral system) in particular, is a pre-requisite for its implementation. This publication is part of a national consultation process in India to increase awareness among key stakeholders about the ITPGRFA and the multilateral system. The process has provided a channel to stakeholders to contribute to the identification of options for how the multilateral system can be implemented in India, building upon existing mandates, organizations, legal frameworks, institutions and strategies. The ITPGRFA expects that contracting parties will provide facilitated access to genetic resources; it also recognizes contributions of local and indigenous communities to the ongoing development and sustainable management of plant genetic diversity. The ITPGRFA represents a big step forward for sustainable agriculture and food security. Bioversity International is engaged in the process of awareness generation and capacity strengthening under the umbrella of the Joint Capacity Building Programme coordinated by the ITPGRFA Secretariat, Bioversity International, and FAO. I am sure that this publication shall provide useful information for stakeholders in India to finalize and follow a road map for the implementation of the ITPGRFA in India. It will help strengthen the overall capacity of actors in the country to implement the ITPGRFA in its letter and spirit, to ensure hassle-free exchange of PGRFA, benefit-sharing, and the effective utilization of the resources, and bring food and nutritional security to the ever growing world population.

Dr S. Ayyappan
Director General, Indian Council of Agricultural Research (ICAR) and
Secretary, Department of Agricultural Research and Education (DARE)

Foreword

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is an operational treaty, which establishes functional systems, in particular the multilateral system of access and benefit-sharing (multilateral system). It needs to process hundreds of daily transactions by numerous institutions and individuals in a concrete, practical and coherent manner. The success and future of the ITPGRFA depends on the practical functioning of its systems at the national level. Implementation at the national level takes place in different phases, from the adoption of policy, legal and administrative measures by the government to ensuring that those measures are complied with and reported on. This is a burdensome task, especially for contracting parties that are developing countries in need of support for the devising of simple, cost-effective and tailor-made instruments and mechanisms. Hence, the need for capacity-building arises.

Capacity-building is embedded in the ITPGRFA and follows two trajectories: it is a mechanism to share the benefits arising from the use of plant genetic resources under the multilateral system; it is also a pillar that sustains the comprehensive and balanced implementation of the entire set of ITPGRFA provisions by developing countries. While the Benefit-sharing Fund looks at the first aspect of capacity-building, the Joint Capacity Building Programme has been set up by the ITPGRFA Secretariat, the Food and Agriculture Organization of the United Nations (FAO) and Bioversity International to trigger the second set of capacity-building activities.

This publication witnesses the steady progress that India is planning to make towards full implementation of the ITPGRFA. It is my hope that the hard work of all the various stakeholders who contributed papers and participated in the national workshop in 2012, and who have been engaged across India working towards putting a system in place to implement the multilateral system will continue their efforts. National implementation requires continuous and sustained efforts at the different policy and administrative levels in all areas concerned by the ITPGRFA. Capacity-building should accompany implementation in all phases, from policy and legislative changes, to administrative support, infrastructure building and human resources development. Recognizing that there is only so much that ITPGRFA Secretariat, FAO and Bioversity International can do under the Joint Capacity Building Programme, I very much hope that all international and national institutions involved in the implementation of the multilateral system will be inspired by the spirit of this publication and follow up as necessary.

Dr Shakeel Bhatti
Secretary, International Treaty on Plant Genetic Resources for Food and Agriculture

Acronyms and Abbreviations

ABS	access and benefit-sharing
BDA	Biological Diversity Act
CBD	Convention on Biological Diversity
CGN	Centre for Genetic Resources
CGRFA	Commission on Genetic Resources for Food and Agriculture
CSIR	Council of Scientific and Industrial Research
DAC	Department of Agriculture and Cooperation
DARE	Department of Agricultural Research and Education
DBT	Department of Biotechnology
EC	exotic collection
ECPGR	European Cooperative Programme for Plant Genetic Resources
EPA	Environment Protection Act
EURISCO	Web-based catalogue of European National Inventories for Plant Genetic Resources
FAO	Food and Agriculture Organization of the United Nations
GB	governing body
GRFA	genetic resources for food and agriculture
GEAC	Genetic Engineering Approval Committee
GR	genetic resources
GRIN	Germplasm Resources Information Network
GMO	genetically modified organisms
GRULAC	Group of Latin American and Caribbean Countries
IARI	Indian Agricultural Research Institute
IBSC	Institutional Biosafety Committee
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IGP	Indo-Gangetic Plains
IP	import permit
IPR	intellectual property rights
IQ	import quarantine
IRGCIS	IRRI's International Rice Genebank Collection Information System
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
International Undertaking	International Undertaking on Plant Genetic Resources for Food and Agriculture

MAT	mutually agreed terms
MCPD	multi-crop passport descriptors
MLS	multilateral system
MoEF	Ministry of Environment and Forests
MoU	memorandum of understanding
MTA	material transfer agreement
NBA	National Biodiversity Authority
NBAP	National Biodiversity Action Plans
NBPGR	National Bureau of Plant Genetic Resources
NBSAPs	National Biodiversity Strategies and Action Plans
OECD	Organization for Economic Co-operation and Development
PBR	plant breeders' rights
PC	phytosanitary certificate
PGR	plant genetic resources
PGREFC	Plant Genetic Resources Export Facilitation Committee
PGRFA	plant genetic resources for food and agriculture
PIC	prior informed consent
PPV&FR Act	Protection of Plant Varieties and Farmers' Rights Act
PQ	plant quarantine
RCGM	Review Committee on Genetic Manipulation
SINGER	System-wide Information Network for Genetic Resources
SMTA	standard material transfer agreement
SP	strategic plan
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UNFCCC	United Nations Framework Convention on Climate Change
UPOV	International Union for the Protection of New Varieties of Plants
USDA	United States Department of Agriculture
WIEWS	World Information and Early Warning System on PGRFA
WTO	World Trade Organization

1 Implementing the multilateral system of access and benefit-sharing in India: setting the scene

R.C. Agrawal, Registrar-General, Protection of Plant Varieties & Farmers' Rights Authority, New Delhi.

P. Brahmi, Senior Scientist, National Bureau of Plant Genetic Resources, New Delhi.

P.L. Gautam, Chairperson, Protection of Plant Varieties & Farmers' Rights Authority, New Delhi.

INTRODUCTION

Given the manner in which crops and forages have developed since the beginning of human civilization, and moved around the world, all countries are now highly interdependent on plant genetic resources for food and agriculture (PGRFA); they rely on PGRFA that exists in, or were originally collected from, other countries. Similarly, sub-regions and even continents are interdependent with regards to PGRFA.

In 1983, recognizing the global importance of PGRFA, the Conference of the Food and Agriculture Organization of the United Nations (FAO) requested the FAO Council to establish the Commission on Plant Genetic Resources, and adopted the International Undertaking on Plant Genetic Resources for Food and Agriculture (International Undertaking), a non-binding agreement that was the forerunner to the International Treaty on Plant Genetic Resources for Food and Agriculture. The International Undertaking envisaged the creation of an internationally coordinated network of *ex situ* collections of PGRFA. It also explicitly stated that PGRFA were the 'common heritage' of humankind. Some countries declined to subscribe to the International Undertaking on the grounds that it did not recognize intellectual property rights (IPRs). In 1989 and 1991, the FAO Council adopted resolutions interpreting the International Undertaking; they recognized IPRs over plant varieties, based on the International Union for the Protection of New Varieties of Plants (UPOV); and national sovereignty over PGRFA.

In 1993, the Convention on Biological Diversity (CBD) came into force. It emphasizes the sovereign right of states over their natural resources and their 'authority to determine access to genetic resources, subject to national legislation'.[1]

Governments negotiating the CBD realized that there were still outstanding issues related to PGRFA that needed to be addressed. To this end, Resolution 3 of the Nairobi Final Act highlighted the need to seek solutions to outstanding matters concerning the global system of conservation and use under FAO, and *ex situ* collections of PGRFA acquired before the CBD came into force.

Thereafter, following the lead established by the Nairobi Final Act, the FAO Council requested the Commission on Genetic Resources for Food and Agriculture to host negotiations for a revision of the International Undertaking, bringing it in line with the CBD. After seven years of negotiations, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was adopted by the FAO Council. The

1 *The full text of the CBD is available at: http://www.cbd.int/convention/text/.*

ITPGRFA came into force on 29 June 2004, and its governing body met for the first time in June 2006. As of now, 128 contracting parties have ratified the ITPGRFA. India is a signatory and ratified the ITPGRFA in June 2002.

Article 10 of the ITPGRFA recognizes the sovereign rights of states over their own PGRFA, including the authority to determine access to these materials. It calls upon contracting parties to facilitate access to their PGRFA through the multilateral system of access and benefit-sharing of the ITPGRFA (multilateral system) so that breeders, for example, can obtain the crop diversity they need for crop improvement, and farmers can acquire the right varieties to meet their needs. In this article, we look at the current status of implementation of the multilateral system in India[2].

THE MULTILATERAL SYSTEM OF ACCESS AND BENEFIT-SHARING

Under the multilateral system, the exchange of germplasm is facilitated through the standard material transfer agreement (SMTA), which is a standardized bilateral contract for the transfer of PGRFA under the multilateral system. This multilateral system contributes greatly to the strengthening of the international genebank system, by creating a pool of important crop genetic resources, which may be accessed by users based in countries that are contracting parties of the ITPGRFA. With regards to intellectual property, the ITPGRFA and the SMTA specify 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'.

To date, over 1.3 million samples of mainly *ex-situ* PGRFA have been made available under the facilitated conditions of an SMTA, by contracting parties, the Centres of the CGIAR Consortium of International Agricultural Research Centres (CGIAR Centres), and other organizations. In addition, the exchange of information on PGRFA in the form of catalogues and inventories, including characterization and evaluation data; the transfer of technologies for the conservation, characterization, evaluation and use of PGRFA; and the development of capacities and facilities for the conservation and sustainable use of PGRFA, including scientific research, are now recognized as mechanisms for non-monetary benefit-sharing to support the conservation and sustainable use of PGRFA within the framework of the multilateral system. The genetic resources of the 64 crops and forages listed in Annex I of the ITPGRFA are automatically included in the multilateral system when they are 'under the management and control' of contracting parties 'and in the public domain'. PGRFA in the multilateral system can be used for the purposes of research, breeding and training for food and agriculture. CGIAR Centres that hold in trust *ex situ* collections of genetic resources have a special relationship with the ITPGRFA. The Centres have placed their materials under the ITPGRFA by signing agreements with its governing body so that their materials would be subjected to the provisions of the ITPGRFA itself. States negotiating the ITPGRFA agreed that any genetic resource exchanged under the multilateral system should not be subjected to intellectual property rights that would limit accessibility to genetic resources in the form in which they were received from the multilateral system. The extent to which intellectual property rights can be applied to material accessed from the multilateral system needs to be further

[2] *The full text of the ITPGRFA is available at: ftp://ftp.fao.org/docrep/fao/011/i0510e/i0510e.pdf.*

deliberated on, in order to determine the effectiveness of the protected commons created in the ITPGRFA.

MECHANISMS FOR REGULATING AND PROTECTING ACCESS TO PLANT GENETIC RESOURCES IN INDIA

With the adoption of the CBD, which advocates national sovereignty over biological resources, national governments were deemed responsible for regulating access to genetic resources; this access is subject to the prior informed consent of the providing country, on mutually agreed terms. India implemented the access and benefit-sharing provisions of the CBD through the enactment of the Biological Diversity Act (BDA) in 2002, which governs access to all the genetic resources of India, and encompasses provisions for equitable benefit-sharing. The ITPGRFA is another legally binding instrument that has provisions for facilitated access to 64 crops and forage species that are included in the multilateral system of access and benefit-sharing, under the terms of an SMTA.

IMPLEMENTATION OF THE ITPGRFA IN INDIA

Representatives from the Department of Agriculture and Cooperation (DAC) in the Ministry of Agriculture in India - mainly from the Joint Secretary (Seeds); and the Indian Council of Agricultural Research (ICAR), actively participated in the long negotiations that led to the adoption of the ITPGRFA, and later became a contracting party to the governing body. Their interaction with the Middle East and South Asia, as a group, and at individual level with the Latin American and Caribbean Group (GRULAC), helped the Indian Government to understand and consolidate the views and stands adopted during these negotiations. This interaction focused specifically on the list of crops to be included in Annex I, the conditions of the SMTA, the role of FAO as the third party beneficiary, and on the funding strategy of the ITPGRFA. India has now designated the DAC in the Ministry of Agriculture, as the nodal agency for the implementation of all the provisions of the ITPGRFA, with the Joint Secretary (Seeds) as focal point.

There are a number of outstanding issues that still need to be worked-out before India can effectively implement the multilateral system under the ITPGRFA. The purpose of this publication is to identify and analyse those outstanding issues, and to develop a road map for implementing the multilateral system in India. Many of the chapters included in this volume were first presented at a national workshop held in New Delhi, in January 2012, entitled 'Strategies for implementing the International Treaty's multilateral system of access and benefit-sharing in India'. (See Appendixes 1 and 2 for the workshop agenda and participant list). One chapter – the next after this introduction – is the inaugural lecture, given by Dr Paroda. The final chapter – the actual road map for the implementation of the multilateral system in India – is based on the collective work of all the workshop's participants. A number of the chapters were developed after the workshop, to provide a more fully-fledged treatment of the relevant issues.

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2 Implementing the International Treaty to address current concerns about managing our plant genetic resources[1]

R.S. Paroda, Former Director General, Indian Council of Agricultural Research (ICAR); Secretary, Department of Agricultural Research and Education (DARE); and Chairman, Trust for Advancement of Agricultural Studies (TAAS).

The organization of planning workshops for strengthening national capacities to implement the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is essential in order to promote the participation of countries in the multilateral system of access and benefit-sharing of the ITPGRFA, and to identify means to improve access to plant genetic resources. For the effective implementation of the multilateral system of access and benefit-sharing (multilateral system) at country level, there are a number of core requirements to be fulfilled, according to the needs of each country. The time has come to move beyond just raising awareness about the ITPGRFA, to develop a road map for its fast and effective implementation.

The institutionalized management of plant genetic resources for food and agriculture (PGRFA) can be viewed with respect to the period leading up to the Earth Summit held in Rio in 1992 (or, pre-summit), and that which followed it. Fortunately, I started learning about genetic resources when there were no such summits. During the pre-summit period, as a student of genetics, I was taught three important things about genetic resources. First, that genetic resources are the building blocks for improving productivity using new genes in plant breeding. Second, that genetic resources are the common heritage of mankind – of course, we say 'humankind' now. Third, that genetic resources are to be freely exchanged for human welfare. Unfortunately, these principles hold no more since the global debate on conservation of biodiversity began in the early nineties.

The United Nations Conference on Environment and Development promoted a major paradigm shift in the management of genetic resources, subjecting them to the rights of nations, which required them to be protected with proper legal instruments. Furthermore, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources were enshrined in the Convention on Biological Diversity (CBD). The CBD, which was adopted in 1992, also envisioned that genetic resources were to be conserved for posterity[2]. Ten years later, during the World Summit for Sustainable Development (WSSD) in Johannesburg, it was realized that conservation is not only required for 'posterity' but also for 'use'. Hence, 'conservation through use' became a common buzz phrase. After several studies, we now know that there is relatively less use of genetic diversity today than before. The Food and Agriculture Organization of the United Nations (FAO), with support from the Bill and Melinda Gates Foundation, has begun a Global Initiative on Plant Breeding (GIPB) to build required capacity for enhanced use of genetic resources.

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1 *Inaugural address delivered in the workshop on 'Strategies for Implementing the International Treaty on Plant Genetic Resources for Food and Agriculture', held on 23 January 2012, at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi.*

2 *The text of the CBD is available at: http://www.cbd.int/convention/text/.*

In the past, India had strong national breeding programmes, especially under the All India Coordinated Research Projects (AICRP), on almost all crops for food and agriculture. Several improved varieties and hybrids were developed under these projects. Today, we seem to have become complacent and more dependent on the pre-breeding materials that are provided by many of the international centres/institutions.

The CBD relates to all forms of biodiversity. But we are greatly concerned with agricultural commodities, including crops, which are immediately necessary for the food and nutritional security of humankind. Thus, a dialogue was initiated under the auspices of FAO to revise the International Undertaking on Plant Genetic Resources for Food and Agriculture[3]. The deliberations culminated in the development of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)[4]. During this time, I was actively associated with a wide range of debates concerning farmers' rights and the revision of the ITPGRFA. At that time, there was a general consensus that only plant breeders should have rights, and even the definition of farmers' rights was not known. I chaired the FAO Working Group on Farmers' Rights, which took almost two years to arrive at a clear definition of farmers' rights. It was then realized that not only plant breeders but also farmers should have rights over their landraces and varieties.

Undoubtedly, all these developments have changed the way that genetic resources are being managed today. In the process, what has happened is that the free exchange of genetic resources has almost stopped. India was among the first countries to ratify the ITPGRFA in 2002. The ITPGRFA came into force in 2004, and in 2006 its governing body adopted the standard material transfer agreement (SMTA) as the instrument for carrying out multilateral germplasm exchange under the ITPGRFA. In India, we envisioned that there would be a bilateral system of germplasm exchange under the CBD, and multilateral exchange under the umbrella of the ITPGRFA. Although the process has not been easy, and no doubt remains slow, still India has moved forward. The Government of India enacted the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001[5], to provide for the establishment of an effective system for the protection of plant varieties, the rights of farmers, plant breeders and researchers; and to encourage the development of new varieties of plants of economic importance. At the same time, the government addressed issues related to the Biodiversity Fund, and access and benefit-sharing mechanisms, by enacting the Biological Diversity Act (BDA), in 2002[6]. I would like to congratulate all those who were involved in these processes, because in many countries similar laws are yet to be formulated or passed by the respective parliaments.

I want to emphasize here that a lot of water has flowed under the bridge. Prior to these international regimes and national laws, genetic resources were being exchanged for faster genetic enhancements. Our food basket today would have been entirely different had we not freely exchanged those genetic resources. There was a lot of debate during the negotiations of the ITPGRFA as to why soybean and some important vegetables should not be included in the Annex I list of crops in the multilateral system of access and benefit-sharing, because they are important food crops. Somehow, these were excluded because of political rather than scientific considerations. Several other crops

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3 *See: http://www.fao.org/Ag/cgrfa/iu.htm.*

4 *The text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

5 *The text of the PPV&FR Act is available at: http://agricoop.nic.in/PPV&FR%20Act,%202001.pdf.*

6 *The text of the Biological Diversity Act is available at: http://nbaindia.org/content/25/19/1/act.html.*

were also discussed, but not included due to the commercial interest of some countries. The decision about the Annex I list of 64 crops (35 food crops and 29 forage species) was taken after intense debate on the last day of negotiations, with the understanding that countries would eventually come forward later and decide if the list should be expanded. Unfortunately, no one is willing to debate and extend the list anymore.

Although the ITPGRFA was ratified almost ten years ago, we are still talking about raising awareness and developing strategies for its implementation! Countries like India, though previously forerunners in using and exchanging PGRFA, have not yet fully implemented multilateral access to those materials under the ITPGRFA that are currently under the domain of FAO and available in the collections of the CGIAR Consortium of International Agricultural Research Centres. A large amount of germplasm of Indian origin was acquired by international genebanks (including CGIAR genebanks) before CBD ratification (1993); this germplasm is being globally exchanged continuously through the ITPGRFA. It is paradoxical that India has yet to agree upon a mechanism under the ITPGRFA to implement the multilateral exchange of Annex I crops, when most of our germplasm is lying in the global multilateral domain. There is a general opinion that India and many other countries are not very open to sharing their respective genetic resources under the obligations of the ITPGRFA. In spite of its great merits, the SMTA has not yet been accepted/adopted by many countries, including India. To address these issues, the Asia-Pacific Association of Agricultural Research Institutions (APAARI), along with Bioversity International, has played a significant role in creating awareness about the enhanced use of genetic resources through multilateral exchange using the SMTA, or bilateral exchange systems based on a mutually agreed material transfer agreement. APAARI, Bioversity International, Rural Development Administration (RDA), the Republic of Korea and the Global Forum for Agricultural Research (GFAR) jointly organized an international symposium on 'Sustainable Agricultural Development and Use of Agrobiodiversity in the Asia-Pacific region' at Suwon in the Republic of Korea, from 13–15 October 2010, in which 84 experts from 32 countries participated. The symposium unanimously adopted the 'Suwon Agrobiodiversity Framework', and provided an opportunity to review and redefine the role and directions of agricultural research and development for the conservation and use of agrobiodiversity, for inclusive agricultural growth and development. It became quite clear that the current situation calls for a better understanding and urgent implementation by the countries concerned, rather than merely raising awareness on the ITPGRFA.

In my opinion, for the general well being of humanity, the pre-CBD era was certainly better than post-CBD. As a result of sovereign rights of nations over their genetic resources in the post-CBD era, several legal and policy dimensions have been added to the handling of PGRFA. A Global Plan of Action (GPA) was adopted in 1996 and has 20 priority activities to address various aspects of the conservation and use of PGRFA[7]. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture, in which I was also associated with two chapters, was published in 2010[8]. The report reviews and assesses the current situation of PGRFA, and reflects on the many interesting lessons that have been learned. A perusal of the report reveals that we need to make a great effort towards strengthening capacity-building and partnerships in order to fulfil our legal obligations; and we must refrain from putting more hurdles in the way

7 *See: http://www.globalplanofaction.org/.*

8 *The full report may be downloaded at: http://www.fao.org/docrep/013/i1500e/i1500e00.htm.*

of implementing our obligations under the ITPGRFA. In fact, with all these negotiations, we have ultimately made things even more difficult. The exchange of genetic resources, which was previously the domain of scientists, is now required to be carried out with the help of bureaucrats, legal experts and farming communities. Thus, in all these developments, issues and concerns need to be looked into more seriously, passionately and in the context of the rights of the beneficiaries, as well as expected benefits to society.

An often-raised question is 'what benefits can be obtained from access and benefit-sharing laws?' In my view, access itself is important, and the ITPGRFA recognizes this in the multilateral system of access and benefit-sharing. Benefit-sharing has long been an unresolved issue. We have been having debates in India with the private seed sector organizations, and a general agreement was reached in which the organizations agreed to share approximately 5% of the sale proceeds from public bred varieties and hybrids. Innovative models must be devised in this regard. Although, the seed industry in India has made great progress with the efforts of the public and private sectors, the private sector organizations have expressed concerns that they are not getting enough genetic resources for crop improvement. With the advent of plant breeders' rights, and the application of intellectual property rights (IPRs) in agriculture, there is a hesitation in sharing germplasm with the private Indian seed industry, for fear of loss of ownership and biopiracy. In fact, now we don't even want to share information on the availability of material, which is a matter of present concern. Hence, there is an urgent need to initiate a process to build trust amongst the various actors, and develop an appropriate mechanism to facilitate the sharing of germplasm between the private sector and the national system.

The farmers are the custodians of many traditional varieties and landraces. Currently, their rights are being protected through the PPV&FR Act. The PPV&FR Authority needs to be congratulated for recognizing farmers' rights, and for being a saviour of farmers' genetic resources. However, we need to see what benefits have gone to the farmers so far. A suitable mechanism must be developed so that farmers can directly benefit from the invaluable services they provide to humankind in protecting rich genetic resources in different hotspots and agro-ecological conditions.

The current state of affairs in the international arena is because those who have not yet accepted and ratified the ITPGRFA are the most vocal people during debates in the international meetings. I had been taking part in these debates but, unfortunately, I find that very few technocrats take part in these debates. Mostly, those debating are either lawyers or bureaucrats. When I used to take part in the debate on farmers' rights there were so many 'clauses' and 'sub-clauses' making things more complicated, and with less substance and clarity. Every time, it was an arduous task to get even one line cleared as there were more than ten legal experts sitting with the delegations of developed nations; whereas developing countries, from where most genetic resources come, were represented by at most one person, and sometimes by no one at all.

The Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization, under the CBD, is open for ratification. India signed it on 11 May 2011, and ratified it on 19 October 2012. It is a matter of great concern that, on the one hand, the international protocols and treaties are signed by the countries, while on the other hand, their direct benefits do not reach society. In order to harness the benefits of these protocols and treaties, a national strategy is urgently needed for the convergence and coordination of all relevant issues/legal requirements to make a step forward so that a targeted section of our society benefits.

The Biological Diversity Act (BDA) is broad, because it encompasses all forms of biodiversity available in nature, including agrobiodiversity. In India, the Department of Agriculture and Cooperation, of the Ministry of Agriculture, is the nodal agency for agrobiodiversity, while the technical aspects are handled by the Indian Council of Agricultural Research (ICAR), which is another wing of the Ministry of Agriculture. Often, ICAR is not invited to participate in these international debates. The creation of many institutions with a lack of convergence and coordination between them also becomes a problem. Therefore, there is an urgent need for a coordinated effort at the national level, for which appropriate institutional mechanisms need to be put in place to make decisions through regular consultations involving all relevant organizations. ICAR recently formed a National Advisory Board on Management of Genetic Resources. The Advisory Board realized in its first meeting that there are many policy issues to be discussed, and in view of this it resolved to move forward with urgency and make several important decisions. It was decided that the Department of Agricultural Research and Education, in coordination with the National Biodiversity Authority, must take immediate steps towards providing access to the germplasm of crops listed in Annex I under the multilateral system as per the provisions of the ITPGRFA. If that happens, this will amount to moving at least one step forwards. It was also decided that information on genetic resources must be made available in the public domain for the purpose of openness in information sharing. The availability of information about the germplasm will not only be useful to share and enhance the utilization, but will also negate the belief that a genebank is merely a 'black box'. It is indeed extremely important for the researchers to know what is available in the genebanks, otherwise these will effectively remain black boxes and will not serve any other useful purpose. Information on all germplasm being held in the genebanks needs to be made available, and made accessible for use through required legal instruments so that it is judiciously used for the benefit of humankind.

Furthermore, there is also a need for the harmonization of different protocols/treaties. This would require better understanding, facilitated by the organization of in-depth discussions and national, regional and global debates from time to time. I congratulate Bioversity International for undertaking activities for awareness generation, with funding support from the Dutch Government. I would like to emphasize that in order to generate awareness at all levels, all the stakeholders, including the researchers, breeders, policy-makers, non-governmental organizations (NGOs) and farmers involved in conservation through use, be included in initiatives on capacity development. Unfortunately, even for the inaugural session of the national workshop entitled 'Strategies for implementing the multilateral system in India,' there were not any policy-makers from the Ministry of Agriculture in the audience, although they are the ones who make the policy decisions. Neither were there NGOs nor many farmers. In the absence of all relevant players, the deliberations and discussions of such important meetings will serve little purpose. If we really mean business, we should do something well planned and more tangible to address the issue of conservation and utilization of plant genetic resources, such as access and benefit-sharing.

I am a strong advocate of the concept of benefit-sharing, and in view of this I have been urging the Chairman of the PPV&FR Authority to garner government support for the creation of an Indian Gene Fund of around Rs. 50 crores (US$ 10 million), which seems to have been included in the 12th Five Year Plan. This fund is for helping farmers and farming communities. It is hoped that the scope of benefit-sharing will increase in the future and that the Gene Fund will expand. Private sector organizations and associations can also be approached to contribute to the Gene Fund. This will be the best step forward to show their solidarity with the national approach. Even the private sector is not sharing germplasm and is not willing to keep it in the National Genebank. This one-way process will not work, and hence, a conclusive dialogue with the private sector is very much needed.

There is an urgent need for partnerships amongst all stakeholders, including public and private sector, NGOs and farmers. Mr. Sunda Ram is a farmer who conserves a large number of collections of different varieties and crops by sheer self-motivation, and without any formal support. The issue to worry about is that if funding support is not forthcoming, there will be no use for the Gene Fund, which was created after much consideration; if the people who conserve the precious germplasm, in the interest of the nation, are not encouraged through appropriate incentives and rewards, the tribal communities will not protect the genetic resources for the benefit of the rest of us while living at the subsistence level. These are issues and concerns that require serious deliberations and call for urgent action.

India is richly endowed with a wealth of genetic resources, which we used to nurture. We have been debating and making a good case for effective and rather urgent implementation of farmers' rights and benefit-sharing with local communities. This process has to be initiated without further delay. That is the way we built the national plan of action during the National Agricultural Technology Project (NATP). The national action plan was prepared in 1998 to be implemented in 'mission mode'. Under the plan, a national germplasm collection programme was launched. Prior to the collection programme being launched, we had 200,000 accessions in the National Genebank at the National Bureau of Plant Genetic Resources (NBPGR). Today, there are over 400,000 accessions, of which 200,000 were collected in just five years, under the NATP project. This was achieved through a participatory approach, by involving all stakeholders. However, this enormous wealth of germplasm must now be systematically characterized, evaluated and shared for effective use. An institute like the NBPGR cannot do this all alone, but it can be achieved through partnership mode, by having a national network programme on the collection, evaluation and supply of genetic resources.

I strongly urge that all the above issues and concerns be addressed jointly by all the stakeholders, especially those working directly with plant genetic resources. Germplasm must be shared more freely in India through the multilateral system, under the ITPGRFA, using the SMTA. This could serve as a good example for the Asia-Pacific region. There are serious challenges before us. Hence, we need to put all our energy and actions together and have a clear road map before us so as to address both the national as well as international concerns more effectively for the benefit of humankind.

Finally, let me conclude by saying that time is running out; business as usual will not help. We need to think globally but act locally, by devising innovative ways to manage our rich genetic resources and serve the society with a human face.

3 Introduction to the International Treaty on Plant Genetic Resources for Food and Agriculture

ITPGRFA Secretariat, FAO, Rome.

INTRODUCTION

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is the only operational international agreement of a legally binding nature with the overall goal of achieving global food security through the conservation and sustainable use of crop diversity and equitable sharing of benefits[1]. The ITPGRFA was adopted by Resolution 3/2001 of the Thirty-first Session of the Conference of the Food and Agriculture Organization of the United Nations (FAO) in November 2001, and entered into force in June 2004. By the end of 2012, 128 countries had become contracting parties to the ITPGRFA.[2]

With the ultimate goal of achieving sustainable agriculture and global food security, the ITPGRFA (Article 1) pursues the following three main objectives:

- Conservation of plant genetic resources for food and agriculture (PGRFA)
- Sustainable use of PGRFA
- The sharing of the benefits arising from the use of PGRFA in a fair and equitable way

The scope of the ITPGRFA extends to all plant genetic resources for food and agriculture (Article 3). However, the multilateral system of access and benefit-sharing, which is created by Part IV of the ITPGRFA, includes only the 64 crop and forage genera listed in Annex I of the ITPGRFA.

To better understand the importance of conserving and exchanging agricultural crops, this introduction will provide some insights into the special nature on plant genetic resources for food and agriculture, as compared to other kinds of genetic resources.

Reliance on human management

Unlike most other genetic resources, agricultural crops are essentially a man-made form of biodiversity. This means that they are not found growing on their own in nature, and for the most part cannot exist without continued human intervention. Agricultural crops have been developed by farmers who have been domesticating wild plants over the millennia, since the very beginnings of agriculture some 10,000 years ago. Through a continuous process of selection and breeding, these plants have been made suitable for agriculture.

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1 *The full text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

2 *For a continuously updated list of contracting parties, see: http://www.fao.org/Legal/treaties/033s-e.htm.*

Undesirable natural traits, such as the shattering of seed-heads prior to maturity, that allow those plants to survive in the wild, have been deliberately bred out, while additional traits that were not previously found in certain plants, such as resistance to drought, have been bred in. Any individual crop variety is thus the product of breeding carried out by many generations of farmers and breeders, possibly stretching across many countries and continents. Without continuous human care most agricultural crops will revert to their wild forms and may be of little further value to food and agriculture.

The plant breeding process calls for a broad range of crop varieties as inputs into the development of successful new varieties. Breeders of commercial varieties may have to screen literally thousands of samples in search of a particular trait. Depending on the crop, breeders commonly work with up to 60 different varieties originating from 20 to 30 different countries. This wealth of parentage means that it is difficult to track the origins of any given crop variety (Fowler, 2003). It is equally complex to calculate the extent to which any particular trait that has been bred into a given new variety is responsible for producing the specific characteristics of that variety.

In both these senses, agricultural crop varieties are unlike other forms of biodiversity. Plant varieties used for the development of pharmaceutical products, for example, are generally wild plants that exist in nature. A given pharmaceutical product may often be derived from a single natural source, with human input limited to the knowledge of the properties of the natural sources.

Interdependence of countries on crop varieties

For centuries, agricultural crops have been freely and widely exchanged across the regions of the world: potatoes originated in the Andes, in Latin America, and are now staple crops in Europe and elsewhere in the world; barley and wheat were first domesticated in the Near East; and rice originated in South-east Asia (FAO, 2001b). The exchange of agricultural crops has continued over the ages, with the result that today almost all countries in the world depend heavily on each other regarding crop diversity for their agricultural development.

The movement of genetic resources for pharmaceutical research has attracted the attention of the media in recent years, as it is often one-directional, from genetically rich countries in the South to industrialized countries in the North. However, in the case of agricultural crops, the flow is more complex. No country or region of the world is entirely self-sufficient in terms of the crop diversity required to sustain and improve its major food crops: the extent of dependence on major food crops is over 50% in most regions of the world.[3] This high degree of interdependence, which is illustrated in Figure 1, is likely to further increase under the growing pressures of climate change. These are the main reasons that motivated the development and adoption of an international agreement that would facilitate access to crop genetic resources for agricultural research and breeding.[4]

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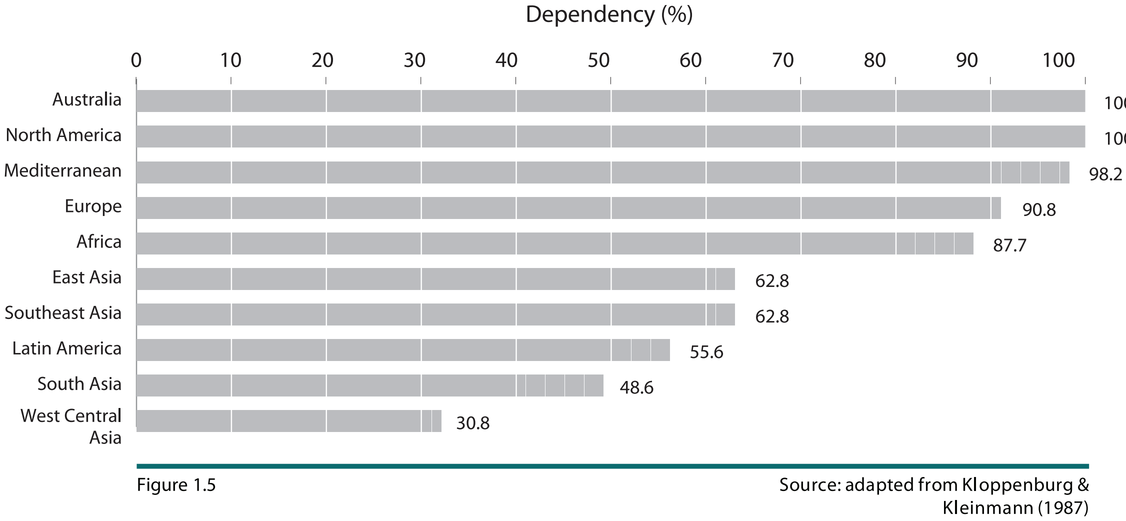
3 *In Central Africa, interdependence ranges from 67% to 94%, and in the Indian Ocean countries from 85% to 100%. At the other end of the scale, we have for example Bangladesh, where the figures range from 14% to 21%.*

4 *Section 1.1 (The Special Nature of Agricultural Crops) is adapted from Moore and Goldberg (2010), pp. 3-5.*

Figure 1: Percentages of food production of major crops, based on species originating from other regions



Source: The State of the World's Plant Genetic Resources for Food and Agriculture (FAO, 1997)

CONSERVATION AND SUSTAINABLE USE OF PGRFA

To ensure that crop diversity is effectively conserved for present and future generations and used in a sustainable way, Articles 5 and 6 of the ITPGRFA propose non-exhaustive enumerations of measures to contracting parties, who commit themselves to integrate such measures into their agricultural policies and rural development programmes (Article 7).

Conservation under the ITPGRFA

The heading of Article 5 indicates that there is more to the conservation of PGRFA than their mere preservation; it reads 'Conservation, Collection, Characterization, Evaluation and Documentation of Plant Genetic Resources for Food and Agriculture'. In accordance with the ITPGRFA, the effective conservation of PGRFA thus comprises all of these aspects.

In a nutshell, conservation is about finding and bringing together samples of as much of the crop diversity that is out there as possible (i.e. collection); determining what exactly it is that is out there, thus the identification of the crop variety, its origins, and the variation in the population (i.e. characterization); identifying the special traits and uses of a given resource, and possible threats it might be exposed to (i.e. evaluation); and compiling all the information and ensuring that it is accessible together with the resource that is being conserved (i.e. documentation).

More concretely, under Article 5 contracting parties agree to undertake the following activities:

- Conduction of surveys and inventories of PGRFA
- Collection of PGRFA and relevant associated information
- Promotion of on-farm and *in situ* conservation of PGRFA and their wild relatives
- Promotion of a system of *ex situ* conservation
- Monitoring and maintenance of collections of PGRFA

The Article highlights the importance of approaching *in situ* and *ex situ* conservation in a complementary way. While emphasizing the role played by farmers, indigenous and local communities in the implementation of *in situ* conservation on farm, it equally underpins the importance of international collaboration for the establishment of an efficient network of *ex situ* collections.

Since the entry into force of the ITPGRFA, substantial progress has been achieved regarding the promotion of an effective system of *ex situ* conservation: in October 2006, the CGIAR Consortium of International Agricultural Research Centres entered into agreements with the governing body of the ITPGRFA. In signing the agreements, the Centres agreed to place their base collections of PGRFA in the multilateral system of access and benefit-sharing (multilateral system). In the meantime, many collections of national genebanks and other organizations have also been officially included in the multilateral system, creating a network that to date contains more than 1.4 million crop samples.

In order to ensure a complementary approach to conservation in the context of the funding strategy of the ITPGRFA, the governing body has made on-farm management and the conservation of PGRFA a priority for the disbursement of financial resources under its direct control. The majority of projects supported by the Benefit-sharing Fund of the funding strategy therefore focus on conservation on farm and *in situ*.

Figure 2: Geographic distribution of genebanks with holdings of >10,000 accessions (national and regional genebanks in blue; CGIAR genebanks in beige; Svalbard Global Seed Vault in green)

Source: The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture (FAO, 2010)

Sustainable use under the ITPGRFA

Neither the concept of 'sustainability' nor 'sustainable use' are defined *per se* in the text of the ITPGRFA. However, using PGRFA in a sustainable way implies making use of crop diversity to meet the food security needs of present generations, without compromising its availability, as the basis of food security for future generations. Possible uses of PGRFA, other than consumption, may include activities such as agricultural research, breeding and cultivation.

Under Article 6, contracting parties agree to adopt measures to promote the sustainable use of PGRFA, including:

- Developing agricultural policies that promote diverse farming systems
- Supporting research that benefits crop diversity and farmers
- Promoting participatory plant breeding
- Broadening the range of genetic material available to farmers
- Promoting locally adapted crops
- Supporting on-farm diversity
- Reviewing regulations concerning variety release and seed distribution

As we can see from these measures, Article 6 focuses on the importance of on-farm management of PGRFA, and on providing farmers with a broad genetic base of crops, as well as on involving farmers in the breeding of locally adapted crops.

The implementation of Article 6 is a standing priority item on the agenda of the governing body. The governing body considers submissions put forward by contracting parties, other governments, and relevant organizations and institutions, with regards to their experiences and progress related to the sustainable use of PGRFA. It does so with the aim of assessing progress and identifying gaps and opportunities concerning the sustainable use of PGRFA. The governing body thereby seeks to facilitate an integrated approach to the sustainable use of PGRFA among contracting parties.

The link between conservation and sustainable use

It is essential to note that the conservation and the sustainable use of crop diversity and its components are intrinsically linked, as reflected in ITPGRFA Article 5.1, which states: 'Each Contracting Party shall [..] Promote an integrated approach to the exploration, conservation and sustainable use of plant genetic resources for food and agriculture [..].'

The practice of *in situ* conservation on farm demonstrates the link between conservation and sustainable use. Through on-farm management, crops are conserved by being cultivated in farmers' fields, notably in the agricultural ecosystems in which they evolved. Thereby, on-farm conservation allows crops to adapt to local conditions by being constantly exposed to them.

Ex situ conservation can be seen on the one hand, as a safety backup measure, while on the other hand, as a measure to facilitate research and breeding of new varieties. In the event a certain variety is wiped out by a natural disaster, for example, it can be reintroduced and used again if it has been stored in a safe genebank facility. In addition,

Box 1: Case study illustrating the promotion of *in situ* conservation on farm through community seed banks: the GREEN Foundation in India

The GREEN Foundation is a community-based organization that has been working since the early 1990s with about 4,200 households spread across 109 villages in Karnataka, India. It aims to preserve and promote crop diversity in this region by conserving the seed of indigenous varieties of plants. In order to do this, the foundation introduced and promoted the concept of community seed banks in conjunction with other organizations working at the grassroots level.

According to the GREEN Foundation, a seed bank is not just a storehouse in which seed is kept for distribution or marketing, nor is it simply a sophisticated storage facility with controlled levels of temperature and humidity; rather, it is an important self-help strategy for maintaining genetic diversity in crop and plant species on farms. It is also a community agricultural system with village-level facilities, such as gardens or fields where traditional varieties are maintained. Through this system, farmers have played a key role in the creation, maintenance and promotion of genetic diversity. They have developed skills to meet their specific needs, such as quality, resistance to pests and pathogens, adaptation to soils, water and climate, etc. Local farmers have established their own seed networks to facilitate seed supply to their families and local markets.

Seed is provided free of charge to members of a seed bank. Anyone from the community can become a member by paying a nominal annual fee. Seed bank members sow seed, harvest the crops, and then return double the amount of seed to the seed bank, in order to replenish the store. The seed banks are managed by women's groups. The women have the capacity to select and store the seed, and maintain germination levels in order to improve seed performance. Their work involves seed mapping, which is a process that is used to gather information about the varieties of seeds that have become extinct or have fallen into disuse, and collect small quantities of them. The foundation then multiplies these seeds by growing them on small plots of land, and establishes seed banks to maintain and manage the distribution of seed produced.

In situ conservation on farm is one of the various methods adopted by the foundation for this purpose; it involves distributing seed diversity among farmers, monitoring the seed using cards, and then collecting seed after the growing season. Seed bank registers, monitoring cards and *in situ* farmers' lists are maintained as part of the conservation element of the activity.

(Adapted from the Centre for Education and Documentation, 2009)

most international and national agricultural research institutions and public and private organizations that maintain collections of germplasm in *ex situ* conditions do so for activities including the characterization, evaluation and documentation of the material, as well as for the breeding of improved varieties. Furthermore, germplasm cannot be stored in a genebank forever; it has to be renewed regularly after a certain period of time to ensure it maintains its germination capacity. As such, seed stored in genebanks also needs to be periodically cultivated, i.e. used.

In this sense, conservation and sustainable use of PGRFA are truly two sides of the same coin. As long as crop diversity continues to be used in a sustainable way, both for cultivation in the fields and for research in laboratories, its use will ensure its conservation. However, active conservation efforts, especially those concerning underutilized crop varieties, ensure the crop diversity remains available for future use.

What makes PGRFA truly unique with regards to other natural resources and most other components of biodiversity is that they are not depleted through overuse; on the contrary, they need to be continuously used in order to be conserved for the future.

Farmers' rights

For the first time in history, the efforts and the enormous contribution made by farmers, including local and indigenous communities, to the development and conservation of crop diversity, has been recognized in an international legally binding instrument. Article 9 of the ITPGRFA advises contracting parties to take measures to protect and promote farmers' rights in accordance with national laws, and provides farmers with the basis to advocate their rights.

Before the adoption of the ITPGRFA, in the absence of an internationally agreed common ground, the concept of farmers' rights meant different things to different people across the world. While some associated it with a desire for a new form of intellectual property rights for farmer-developed materials, others saw it as a kind of political slogan, for seeking recognition of farmers' contributions to the conservation and sustainable use of PGRFA, and support for their activities in this regard. To many it also meant protecting the ability of farmers to continue to conserve and use PGRFA in a sustainable way; and enabling farmers to take an active part in decision-making related to crop diversity (Fowler, 1997).

Article 9 clarifies the issue by providing the internationally agreed common ground that was lacking prior to the adoption of the ITPGRFA. It notably provides the following list of measures for contracting parties to take at the national level for the protection and promotion of farmers' rights:

- The *protection of traditional knowledge* relevant to PGRFA
- The *right to participate in the sharing of benefits* arising from the use of PGRFA
- The *right to participate in decision-making* related to PGRFA.

This list of measures is a non-exhaustive, indicative list. It is important to note, however, that Article 9 states clearly that the implementation of farmers' rights falls under the responsibility of national governments, and the adoption of the above, and other, measures for the promotion of farmers' rights remains thus at the discretion of national authorities.

In addition to these measures, the importance of the rights of farmers to save, use, exchange and sell farm-saved seed is affirmed in the preamble of the ITPGRFA. However, the provisions of Article 9 are neutral with respect to the so-called 'farmers' privilege', which is a term derived from the field of plant variety protection. The ITPGRFA acknowledges that farmers may have such rights in certain national settings, and reaffirms that where farmers do have these rights, there is no way that they could be limited by the provisions of Article 9 (Moore and Tymowski, 2005).

Box 2: The linkages between traditional knowledge and food security

Millions of traditional farmers, and indigenous and local communities, use their traditional knowledge to ensure food and livelihood security in a wide range of ecosystems, including those that are fragile and harsh. Traditional practices are related to cultural traditions and bio-cultural dynamics, and can regenerate local food systems while increasing socio-environmental sustainability and resilience. Such practices can also be applied in innovative ways to help tackle today's problems.

Worldwide, 2.5 billion people derive their livelihoods from agricultural resources; 900 million poor people live in rural areas; and 720 million – 400 million of whom are indigenous peoples – directly depend on agriculture and related activities. Traditional knowledge of food and agriculture has existed for millennia, and has evolved over the last 10,000 years with the domestication of plants and animals and the development of agriculture.

Over the years, rural people have generated traditional knowledge related to the thousands of indigenous crop and plant varieties, animal breeds, landraces and wild species that they use as food, medicinal and other products to ensure food and livelihood security. Today, throughout the world, 10,000 cultures and 6,900 languages are involved in thousands of traditional knowledge systems. Traditional knowledge is maintained by experts and non-experts in local communities; it is held, owned and developed both collectively and individually; and it is transmitted through written, oral and non-verbal means among and within cultures, generations, population groups, communities, households and individuals.

The concept of farmers' rights is intrinsically linked to the traditional knowledge of farmers and indigenous and local communities. The ITPGRFA is the first international legally binding instrument that endorses these rights and acknowledges the enormous contribution made by local and indigenous communities and farmers from all regions of the world, to the conservation and development of PGRFA.

(Adapted from FAO, 2009c)

Farmers' rights, as defined in Article 9, are backed by other provisions of the ITPGRFA, including the preamble, as well as a number of the measures proposed for the promotion of the conservation and sustainable use of PGRFA that were summarized in the previous section. Certain provisions linked to benefit-sharing under the multilateral system, and to the funding strategy, are also supportive of farmers' rights.[5]

The Secretary of the ITPGRFA regularly compiles views on farmers' rights and experiences with their implementation by contracting parties and other relevant organizations for the consideration of the governing body (ITPGRFA, 2009a). A number of contracting parties have expressed uncertainty about how to best implement farmers' rights. To facilitate the exchange of views and experiences among stakeholders and contracting parties, the governing body decided to convene consultations on farmers' rights and integrate a farmers' rights component into the programme of work on sustainable use.

5 *Notably Arts. 5.1 c), 5.1 d), 6.2 b), 6.2 c), and 6.2 d) in the context of conservation and sustainable use; 12.3 e), 13.2 b) iii), 13.2d), and 13.3 in the context of the multilateral system; and 18.5 in the context of the funding strategy.*

THE MULTILATERAL SYSTEM OF ACCESS AND BENEFIT-SHARING

The multilateral system constitutes the core mechanism of the ITPGRFA. It is instrumental to achieving the objectives of the ITPGRFA, i.e. the conservation and sustainable use of PGRFA, and the fair and equitable sharing of benefits arising from their use. The entire part IV of the ITPGRFA, i.e. Articles 10–13, is dedicated to the multilateral system.

The most immediate advantage for a contracting party is that any natural or legal person under its jurisdiction enjoys facilitated access to the vast range of crop samples contained in the global gene pool of the multilateral system for purposes of agricultural research and breeding. Natural and legal persons include, among others, national genebanks and research institutions, individual breeders and farmers, non-governmental organizations, as well as public and private breeding companies.

By the end of 2011, this global gene pool comprised more than 1.4 million unique samples of crop varieties, and more are continuously being added to it. Facilitated access to the global gene pool favours the development of new varieties with higher yields, for instance, or with resistance to stresses induced by climate change, such as drought, salinity or pests.

Thanks to the ITPGRFA, it has become easier to locate existing crop samples. Contracting parties, and other entities that formally include their samples in the multilateral system, notify the Secretariat of the ITPGRFA about their inclusions, and all formal notifications are published online.[6] In addition, the Secretariat is working towards the more efficient coordination and integration of existing web-based catalogues and other information technology systems that make it easier to search for PGRFA. Another main element of facilitated access under the ITPGRFA is that complicated procedures and time-consuming negotiations of specific contracts for exchanges of PGRFA are eliminated. A breeder who would like to receive a given crop sample from a certain genebank collection, for example, can simply do so according to the terms of the standard material transfer agreement (SMTA).

The SMTA is a standard contract for use in the transfer of crop samples under the multilateral system, which has been negotiated and agreed internationally (i.e. by the governing body of the ITPGRFA). It provides a transparent set of terms and conditions and thus guarantees legal security in the exchange of PGRFA.

Sharing the benefits arising from the use of crop diversity

Contracting parties and stakeholders within their jurisdictions have the possibility to receive a share of the benefits arising from the use of the PGRFA that are exchanged under the multilateral system. Once crop genetic material has been included in the common gene pool of the multilateral system, this material falls under the shared competence of all contracting parties for the benefit of humanity. Accordingly, a country that has placed a specific crop sample in the gene pool cannot expect to benefit individually in return. In fact, the benefits that arise from the use of material from the multilateral system are shared in a multilateral way.

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6 *For inclusions of PGRFA into the multilateral system see: http://www.planttreaty.org/inclusions.*

Benefits are shared according to internationally agreed priorities for the conservation and sustainable use of crop diversity, and taking into account the needs of contracting parties. On this note, the ITPGRFA foresees that benefits flow primarily to farmers who conserve and sustainably utilize crop diversity, especially in developing countries and countries with economies in transition. More concretely, the ITPGRFA foresees the sharing of both non-monetary and monetary benefits arising from the use of the material contained in the multilateral system.

Options for non-monetary benefit-sharing include:

- *Exchange of information* related to PGRFA, such as inventories, information on technologies and relevant research results
- *Access to, and transfer of, technology* for the conservation and sustainable use of PGRFA that are part of the multilateral system
- *Capacity-building* in developing countries, primarily related to conservation and sustainable use, by, for example, developing and strengthening facilities for those purposes, and carrying out scientific research

Any financial returns arising from the sharing of benefits are placed in the Benefit-sharing Fund, which is an international trust fund that invests in high impact projects for the conservation and sustainable use of crop diversity. The fund has a fundraising target of US$ 116 million over a five-year period ending December 2014.

Any governmental or non-governmental organization, including genebanks and research institutions, farmers and farmers' organizations, and regional and international organizations, based in developing countries that are contracting parties to the ITPGRFA, can apply for financial support from the Benefit-sharing Fund.

A global gene pool for the benefit of humanity

The contracting parties of the ITPGRFA created the multilateral system, within the framework of which they grant each other facilitated access to a number of their most important food crops and forages. The multilateral system can be thought of as a global pool of PGRFA that are shared and managed jointly by all contracting parties of the ITPGRFA, and from where PGRFA can be obtained on standardized terms. The SMTA was adopted by the governing body to regulate transfers of material that is contained in this global gene pool. The SMTA provides transparent regulations that guarantee legal security in exchanges of PGRFA. It thereby prevents misuse of the material that is being exchanged and ensures that the benefits arising from commercial use of material from the multilateral system will be shared in a fair and equitable way among contracting parties.

This global gene pool, however, is not physically located in one single place in the world. On the contrary, it is a global network of international and national genebanks and other institutions that hold PGRFA – a virtual gene pool, so to speak.

Coverage of the multilateral system

The coverage of the multilateral system is limited to the genetic material of the 64 food crops and forages listed in Annex I of the ITPGRFA, which are generally referred to as

Box 3: Sovereign rights over PGRFA

Countries have sovereign rights over their PGRFA. Sovereign rights over PGRFA are grounded in the Charter of the United Nations and the principles of international law, and are formally recognized in the CBD. The fact that the contracting parties of the ITPGRFA grant each other facilitated access to a number of the most important crops for food security, by including them in the multilateral system, does not mean that they renounce their sovereign rights over these resources. Rather, they make use of their sovereign rights to place their PGRFA in the multilateral system for the benefit of the international community (Article 10, ITPGRFA). Thus, both the multilateral system and the CBD equally respect the sovereign rights of countries over their PGRFA.

'Annex I crops' (Articles 3 and 11). The list of Annex I crops has been defined according to the following two criteria:

- Importance for global *food security*
- *Interdependence*, or the degree to which countries depend on other countries and regions for genetic material of a given crop for their agricultural research and breeding activities

The Annex I list was negotiated and agreed-upon by all contracting parties in the spirit of compromise. It is for this reason that some crops of importance to food security, such as soybean and tomatoes, are not included in Annex I. It is important to note, however, that the coverage of the multilateral system is not carved in stone; it is within the governing body's capacity to re-open negotiations on the crops to be included in Annex I.

Contracting parties commit to include in the multilateral system all PGRFA listed in Annex I that are under their management and control and in the public domain (e.g. material stored in national genebanks). Furthermore, they invite other holders of PGRFA within their jurisdiction, including natural and legal persons (e.g. individuals, civil society organizations and the private sector) to include their Annex I material in the multilateral system. In addition to that, the Annex I material held by CGIAR Centres and other international institutions that enter into special agreements with the governing body, forms part of the multilateral system.

To date, the main contributors of PGRFA to the multilateral system are CGIAR Centres, a number of other international institutions, national genebanks of contracting parties and also some natural and legal persons. At present, the multilateral system contains over 1.4 million samples of germplasm, and 600–800 samples are being exchanged under the terms of the ITPGRFA on a daily basis.

The material can only be accessed for the purpose of utilization and conservation for research, breeding and training activities related to food and agriculture. The use of material for other reasons, such as chemical or pharmaceutical research, is not permitted (Article 12.3a). Any charges for the transfer of materials, such as shipping costs, are nominal if at all requested by the provider of the materials. In addition, the provider has the obligation to make associated descriptive data available to the recipient together with the plant genetic material (Articles 12.3b and 12.3c). Recipients, in turn, cannot claim any intellectual property right over the material in the form in which they receive it from the multilateral system, nor on any genetic part or component thereof. If recipients conserve the material, they are bound to continue to make it available to subsequent users (Articles 12.3d and 12.3g, ITPGRFA).

Benefit-sharing under the multilateral system

In Article 13, the ITPGRFA foresees several options, both monetary and non-monetary, for benefit-sharing arising from the commercialization of material accessed from the multilateral system. The contracting parties have agreed that such benefits should flow primarily to farmers in developing countries who promote the conservation and sustainable use of PGRFA (Article 13.3).

As seen above, mechanisms for non-monetary benefit-sharing include:

- *Exchange of information* related to PGRFA, such as inventories, information on technologies and relevant research results (Article 13.2a)
- *Access to and transfer of technology* for the conservation and sustainable use of PGRFA that are part of the multilateral system (Article 13.2b)
- *Capacity-building* in developing countries, primarily related to conservation and sustainable use of PGRFA, including through developing and strengthening local facilities, and carrying out scientific research (Article 13.2c)

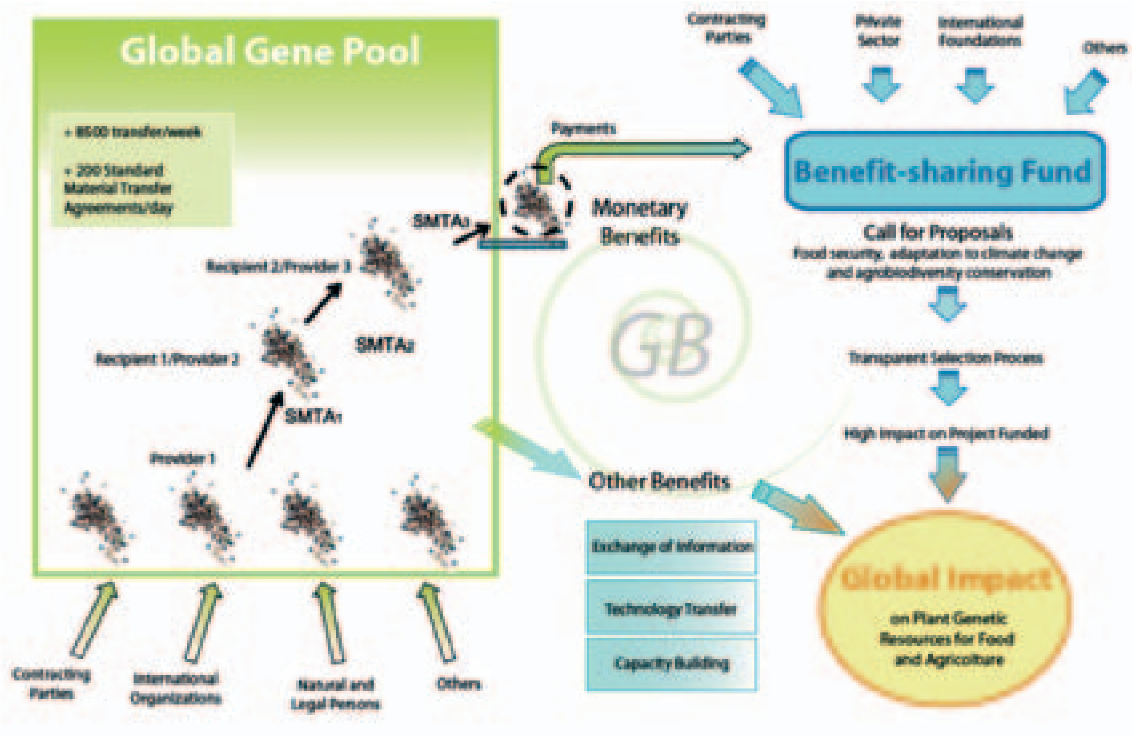
Anyone who commercializes a new crop variety that incorporates traits from plant genetic material originating from the multilateral system is encouraged to pay an equitable share of commercial profits from its subsequent use into the Benefit-sharing Fund. The Benefit-sharing Fund, which is under the exclusive control of the contracting parties to the ITPGRFA, is part of the funding strategy of the ITPGRFA.

In the event that the new variety is no longer available to others for further research and breeding, a share of the profits must be paid into the Benefit-sharing Fund. This would happen, for example, if a breeder takes out a patent on new material, which does not allow for facilitated access according to the terms of the ITPGRFA. In such a case, the share of the profits that is to be paid into the Benefit-sharing Fund is determined in the SMTA entered into by the provider and the recipient of the original material from the multilateral system at the moment of transferring the material; specifically the share comprises 1.1% of net sales less 30%, or 0.77% of gross sales (Article 13.2d.ii).

THE BENEFIT-SHARING FUND

The Benefit-sharing Fund is an innovative mechanism that seeks to share the global benefits that arise from the use of PGRFA with those who actively contribute to the conservation and sustainable use of crop diversity. The Benefit-sharing Fund supports initiatives that focus on the on-farm management and conservation of PGRFA and the sustainable use of PGRFA, in developing countries that are contracting parties of the ITPGRFA. The Benefit-sharing Fund is a trust account that was set up to collect the financial resources that arise from monetary benefit-sharing resulting from commercialization, as

Figure 3: Flow of material and benefits within the multilateral system



Source: ITPGRFA Secretariat (2009)

referred to above in the context of the multilateral system. In addition, it can also receive voluntary contributions from contracting parties, international institutions, foundations, the private sector and other possible sources (Articles 13.2d.ii and 18.4f).

The Benefit-sharing Fund is thus fed by the first two sources illustrated in Table 1 below: financial resources from monetary benefit-sharing and voluntary contributions. In fact, to date, the Benefit-sharing Fund relies entirely on voluntary contributions. This is mainly because the process of developing a new crop variety up until its commercialization takes about 10–15 years. Consequently, since the ITPGRFA only entered into force in 2004, mandatory monetary benefit-sharing from commercialization cannot realistically be expected before 2015–2020.

Thanks to early contributions made by contracting parties,[7] the governing body was able to launch the first call for proposals of the Benefit-sharing Fund in 2009. A total of US$ 550,000 was allocated to eleven small-scale projects in developing countries over a period of two years. In Peru, for example, the Benefit-sharing Fund supported the Potato Park of the Association for Nature and Sustainable Development (ANDES). This project aims to enhance the capacity of local farmers to adapt their traditional potato varieties to climate change.[8] This first round of projects supported by the Benefit-sharing Fund can be seen as the pilot implementation phase of the Benefit-sharing Fund.

[7] *The first donors included the governments of Italy, Norway, Spain and Switzerland.*

[8] *For a short description of the first projects funded under the Benefit-sharing Fund, see: ftp://ftp.fao.org/ag/agp/planttreaty/funding/pro_list09_01_en.pdf.*

Table 1: Sources of the funding strategy

1. Sources under the direct control of the governing body		
Financial resources resulting from *monetary benefitsharing from commercialization*.	*Voluntary contributions* from contracting parties, the private sector, and other organizations and institutions.	Financial resources provided through the *Regular Programme of FAO*.
2. Sources not under the direct control of the governing body		
Resources allocated through *bilateral, regional and multilateral channels*.	Resources allocated by other *international mechanisms, funds and bodies*.	Resources allocated through *national activities* of contracting parties.

Source: Strategic Plan for the Implementation of the Benefit-sharing Fund of the Funding Strategy. http://www.planttreaty.org/content/strategic-plan-implementation-benefit-sharing-fund-funding-strategy

In 2009, the governing body also approved the strategic plan for the implementation of the Benefit-sharing Fund of the funding strategy (hereafter, strategic plan). The strategic plan, as illustrated in Table 2, established a funding target of US$ 116 million for the Benefit-sharing Fund, to be reached over the five-year period between July 2009 and December 2014 (ITPGRFA, 2009b).

Thanks to subsequent contributions from contracting parties and institutional donors, the Secretariat opened the second call for project proposals in July 2010. The thematic focus of the second call for proposals was on ensuring sustainable food security by assisting farmers to adapt to climate change through a targeted set of high impact activities. For this second project cycle of the ITPGRFA, the Benefit-sharing Fund has been able to invest US$ 6 million.[9]

THE FUNDING STRATEGY

The ITPGRFA has created a funding strategy to facilitate the mobilization of financial resources to achieve its objectives. The funding strategy notably aims at supporting contracting parties in their efforts to implement the national measures required to meet the objectives of the ITPGRFA. It was adopted at the first session of the governing body in 2006, based on Article 18 of the ITPGRFA (ITPGRFA, 2006).

The funding strategy comprises resources over which the governing body has direct control, as well as resources contributed by other entities that are not under the direct control of the governing body, for the implementation of the objectives of the ITPGRFA. Resources that are not under the direct control of the governing body include those financial resources that contracting parties invest within their own national context in policies, programmes and projects for the conservation and sustainable use of crop diversity. In addition, they embrace all those financial resources that are channelled into projects and programmes aimed at implementing the objectives of the ITPGRFA through bilateral, regional and multilateral cooperation among contracting parties. A third and important category of sources of funding that are not under the direct control of the

[9] *The major donors of the second call for project proposals included the governments of Australia, Ireland, Italy, Norway and Spain. All relevant information on the 2010 call for proposals, is available at: http://www.planttreaty.org/content/benefit-sharing-fund.*

Table 2: Plan to secure the US$ 116 million objective in commitments over a five-year period

	Year 1 (18 months)	Year 2	Year 3	Year 4	Year 5
Cumulative target (USD million)	10	27	50	80	116
Annual target (USD million)	10	17	23	30	36
# Contracting party contributions	5–7	6–8	6–8	10–14	10–14
% Contributed by contracting party	98–100%	90–95%	90–93%	80–85%	75–85%
# Other contributors	0–3	2–4	4–6	6–10	8–12

Source: Strategic Plan for the Implementation of the Benefit-sharing Fund of the Funding Strategy. http://www.planttreaty.org/content/strategic-plan-implementation-benefit-sharing-fund-funding-strategy

governing body include those financial resources that are allocated by international mechanisms, funds and bodies other than the ITPGRFA, but which pursue the same objectives and therefore contribute to the implementation of the ITPGRFA.

One of the major groups of resources that are not under the direct control of the governing body is that created and managed by the Global Crop Diversity Trust (Crop Trust). The Crop Trust administers an endowment fund that was established in 2004 with the aim of conserving crop diversity in perpetuity. Its work focuses notably on strengthening the global system of *ex situ* conservation by supporting the activities of major genebanks around the world. Together with the Government of Norway, the Crop Trust covers the maintenance costs of the Svalbard Global Seed Vault. The governing body of the ITPGRFA officially welcomed the Crop Trust as an essential element of its funding strategy, in relation to *ex situ* conservation and the availability of PGRFA. The funding target of the Crop Trust is US$ 260 million, which would generate approximately US$ 12 million per year. To date, it has raised over US$ 150 million.[10]

Some of the resources that are under the direct control of the governing body are used for the organization of the regular sessions of the governing body, and the inter-sessional meetings of subsidiary bodies and expert groups. This also includes the work of the Secretariat of the ITPGRFA in preparing for these meetings and carrying out the tasks accorded to it by the governing body.

An important share of the resources under the direct control of the governing body flows directly into initiatives for the conservation and the sustainable use of PGRFA in developing countries. These are mainly contributions that are allocated for this purpose to the Benefit-sharing Fund, as discussed above. Financial resources resulting from monetary benefit-sharing from commercialization will also flow into the Benefit-sharing Fund.

[10] *Status 31 December 2010.*

GOVERNANCE OF THE ITPGRFA

The governing body is the supreme decision-making body of the ITPGRFA, and comprises all contracting parties – i.e. those countries that have formally ratified, accepted, approved or acceded to the ITPGRFA. Its core function is to promote the full implementation of the ITPGRFA. The sessions of the governing body take place at least every two years to review the progress and programme of work of the ITPGRFA. The representatives of the contracting parties meet to make the necessary decisions for the gradual implementation of the ITPGRFA.[11] The governing body provides, *inter alia*, policy direction and guidance, and adopts plans, programmes and budgets. It may also establish subsidiary bodies (e.g. *ad hoc* committees); launch inter-sessional processes; and consider and adopt amendments to the ITPGRFA (Article 19). The decisions of the governing body are made by consensus among contracting parties. For example, the governing body adopted the SMTA and the funding strategy at its first session in 2006, and, at its third session in 2009, it adopted the strategic plan for the implementation of the Benefit-sharing Fund of the funding strategy.

The Bureau of the ITPGRFA is composed of the Chairperson and the Vice-Chairpersons of the governing body, one for each FAO region, which makes a total of seven Bureau members[12]. The Bureau members are elected by the governing body for the period in between two sessions, and ensure coordination among the contracting parties of their region (Article 19.11). The Bureau meets in the inter-sessional period in order to discuss topics to be addressed by the governing body; it oversees the progress of the subsidiary bodies, and processes and provides guidance to the Secretary. For example, in the context of the project cycle under the Benefit-sharing Fund, the Bureau assumes the role of selecting the project proposals to be funded.

The Secretary is appointed by the Director-General of FAO. The Secretary works together with a staff, jointly referred to as the Secretariat, the main function of which is to provide practical and administrative support for the sessions of the governing body and to assist the governing body in carrying out its functions. The Secretary carries out tasks defined by the governing body, establishing and maintaining partnerships and cooperation with other relevant organizations and institutions. The Secretariat also provides support for the Bureau and any other subsidiary body established by the governing body, through the organization of meetings of these bodies and the preparation of necessary documentation. In addition, the Secretary communicates the decisions of the governing body, as well as any information received from contracting parties in accordance with the provisions of the ITPGRFA, to contracting parties and to the Director-General of FAO (Article 20).

In order to advance the work of the governing body in the period between two sessions, a number of subsidiary bodies have been established. The subsidiary bodies are composed of experts who are selected on a regional basis. These experts deliberate on the further implementation of certain components of the ITPGRFA, and prepare strategies and legal texts for consideration and adoption by the governing body.

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[11] *For an overview of the reports and working documents of past sessions of the governing body, see: http://www.planttreaty.org/governing_body_sessions.*

[12] *FAO member states are grouped in seven regions, namely: Africa, Asia, Latin America and the Caribbean, Near East, North America, South-west Pacific.*

The following subsidiary bodies have been established to date:

- *Ad hoc* advisory committee on the funding strategy
- *Ad hoc* technical advisory committee on the standard material transfer agreement and the multilateral system
- *Ad hoc* working group on compliance (now mutated into the compliance committee)
- *Ad hoc* third party beneficiary committee
- *Ad hoc* technical committee on sustainable use

The national focal points are the contact persons appointed by the governments of contracting parties. They ensure the link between the international and the national levels for all matters related to the ITPGRFA. The Secretariat channels its communications to contracting parties through their national focal points. The role of the national focal points is to communicate and coordinate issues related to the ITPGRFA with the relevant institutions and officials at the national level, as appropriate. In order to facilitate the communication among contracting parties, a list with the contact details of national focal points is available online.[13] Contracting parties that have not yet nominated a national focal point are invited to do so through their competent ministries.[14]

Advantages of being a contracting party of the ITPGRFA

On a general level, contracting parties benefit from the guidance provided by the ITPGRFA for the elaboration of national laws and policies related to crop diversity. A main, direct advantage is that agricultural researchers and breeders of a contracting party enjoy facilitated access to the global pool of crop samples of the multilateral system. At the same time, contracting parties, and stakeholders within their jurisdiction, have the possibility to receive a share of the benefits that arise from the use of these crops. At the political level, a contracting party can ensure that its national needs and interests related to PGRFA are taken into consideration by the international community. The fact that the decisions of the governing body are made by consensus ensures that the outcomes are balanced and that all contracting parties have an equal say in the decision-making process. Countries that are not contracting parties of the ITPGRFA are not eligible to receive financial support under the benefit-sharing mechanism of the multilateral system, nor will they receive alternative support in the form of capacity-building.

CONCLUSION

The ITPGRFA is an operational treaty, in the sense that it is continuously being further developed and implemented by its contracting parties. The provisions related to conservation and sustainable use of PGRFA highlight the need for a complementary approach to *in situ* and *ex situ* conservation. Moreover, they emphasize the inherent linkage between the conservation and the sustainable use of crop diversity. The underpinning logic of the ITPGRFA is that conserving PGRFA is of limited value if it is not done with the aim of subsequently using them for agricultural research and breeding, and finally cultivation and consumption.

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13 *See: http://www.planttreaty.org/nfp.*
14 *Nominations should be sent to pgrfa-treaty@fao.org.*

The ITPGRFA is the first legally binding international agreement that acknowledges the contribution of farmers all over the world to the development and conservation of crop diversity. While the implementation of measures to promote farmers' rights remains at the discretion of national authorities, the ITPGRFA advises contracting parties to implement national regulations related to farmers' rights and provides farmers with a basis to advocate their rights.

The multilateral system is the core mechanism of the ITPGRFA. It can be thought of as a global pool of PGRFA that is shared and managed jointly by all contracting parties of the ITPGRFA, and from where PGRFA can be obtained on standard terms.

The 1.4 million samples of germplasm in the multilateral system can be accessed for the purposes of agricultural research and breeding according to a standard contract, the SMTA. The SMTA facilitates exchanges of PGRFA and ensures that commercial benefits are shared in a fair and equitable way.

The Benefit-sharing Fund substantiates the monetary benefit-sharing component of the multilateral system. It has a funding target of US$ 116 million by 2014. The fund became functional in 2009, and in 2010 opened its second call for project proposals. For this second project cycle the Benefit-sharing Fund will invest more than US$ 10 million in initiatives aimed at the conservation and sustainable use of PGRFA in developing countries that are contracting parties of the ITPGRFA, and that have a focus on helping ensure sustainable food security by assisting farmers to adapt to climate change.

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4 India's ratification of the International Treaty on Plant Genetic Resources for Food and Agriculture: when, why, how

D.S. Mishra, Joint Registrar, Protection of Plant Varieties and Farmers' Rights Authority, New Delhi.

S.K.G. Rahate, Joint Secretary - Seeds; Technology Mission on Oilseeds and Pulses (TMOP); Plant Protection (PP); and Machinery, Department of Agriculture and Cooperation, Ministry of Agriculture, New Delhi.

INTRODUCTION

After seven years of negotiations, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was finally adopted at the Food and Agriculture Organization of the United Nations (FAO) Conference, in November 2001[1]. India is a founding member of the ITPGRFA. India participated in all the international negotiations that led up to the adoption of the ITPGRFA, and was one of the first countries to both sign and ratify it. India also actively participated in negotiations for the development of the standard material transfer agreement (SMTA), which took place after the ITPGRFA entered into force.

The Government of India made a conscious decision, in consultation with major stakeholders to be a signatory to the ITPGRFA in June 2002. The Department of Agriculture and Cooperation (DAC) of India, under the Ministry of Agriculture, as the nodal agency for the implementation of ITPGRFA, prepared and submitted a note to the Cabinet in support of India becoming a contracting party to the ITPGRFA. All the major departments and organizations supported the DAC's proposal. India signed and ratified the ITPGRFA on 10th June 2002, having obtained the approval of the Cabinet.

This paper focuses on a number of overlapping factors that motivated India to ratify the ITPGRFA so quickly. In short, those factors are related to the fact that the ITPGRFA promotes access to plant genetic resources for food and agriculture (PGRFA) and benefit-sharing related to their use; the conservation and sustainable use of PGRFA; and farmers' rights. All of these objectives are in line with India's own national priorities.

FACTORS THAT INFLUENCED THE RATIFICATION OF THE ITPGRFA BY INDIA

The ITPGRFA promotes access to PGRFA needed for conservation, research and breeding

Plant genetic resources for food and agriculture create the foundation for our ability to feed the world's human population. They provide the raw materials that farmers and plant breeders use to improve the quality and productivity of our crops. The future of agriculture depends on international cooperation and on the open exchange of crops and their genetic materials. Farmers all over the world have been developing and exchanging PGRFA for over 10,000 years. No country is completely self-sufficient; we all depend on crops, and the genetic diversity within these crops, from other countries and regions.

[1] *The full text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

Until the end of the last century, crop genetic resources were managed as goods in the public domain, according to a set of practices loosely labelled as 'common heritage of mankind.' Common heritage refers to the treatment of genetic resources as belonging to the public domain and not owned or otherwise monopolized by a single group or interest. The roots of the concept are visible in the free exchange of seed among farmers, the long history of diffusion through informal and formal mechanisms, established scientific practices, and the application of the term to other resources internationally.

References to crop genetic resources as a common heritage appeared in the 1980s, in association with the establishment of the Commission on Plant Genetic Resources, and the launching of the International Undertaking of Plant Genetic Resources, at the FAO Conference in 1983[2]. With regards to plant resources, common heritage implies open access to seeds and plants from farmers' fields, as well as from companies' and governments' collections. Over the years, seed has been collected in different ways by consular officers, travellers, missionaries, students and scientists; and, since the early 20th century, by official collecting missions.

The logical foundation of common heritage is in the very nature of crop genetic resources, the universal processes of diffusion and dispersal, and the historical practices of reciprocity. Crop genetic resources derive originally from natural and amorphous processes, or from crop evolution, mutation, natural selection, exchange, and decentralized selection. Because no person or group controls crop evolution, it is inappropriate for anyone to claim authorship or ownership. Likewise, the tangled history of diffusion and dispersal not only obscures origin, but suggests that all farmers benefit from the fluid movement of seed. Farmers who openly provide seed expect to receive it in the same manner, and the same is true for crop breeders. Neither common property nor common heritage implies a lack of rules governing the use and management of common assets. One implicit rule concerning the common heritage of crop genetic resources is the rule of reciprocity: those who take seeds are expected to provide similar access to their crop resources. The flow of seed within farming villages illustrates this reciprocity, but it is also evident in the movement of seed beyond the village and into the international system of collecting and using genetic resources.

Through the ITPGRFA, countries agree to establish an efficient, effective and transparent multilateral system to facilitate access to plant genetic resources for food and agriculture, and to share the benefits in a fair and equitable manner. This multilateral system of access and benefit-sharing (multilateral system) applies to over 64 major crops, which include 35 food crops and 29 forages. The governing body of the ITPGRFA, which is composed of representatives of member countries, known as contracting parties, has set out the conditions for access and benefit-sharing in the form of a standard material transfer agreement (SMTA). Obligations arising under such SMTAs rest exclusively with the parties to those agreements.

The multilateral system is built upon the recognition that plant genetic resources for food and agriculture are essential raw materials for crop genetic improvement. The ITPGRFA ensures access to plant genetic resources throughout the world, for the creation of new plant varieties.

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2 *See: http://www.fao.org/Ag/cgrfa/iu.htm.*

Although India has a high genetic diversity in a number of crops such as rice, banana and yams, the genetic diversity in India in some major cereal crops, such as wheat, maize, pearl millet and sorghum, is not sufficient for long-term national breeding programmes. The ITPGRFA should, therefore, benefit India by facilitating germplasm exchange for its food and nutritional security.

The ITPGRFA promotes benefit-sharing related to the use of PGRFA and farmers' rights

Developing nations that are rich in genetic resources but economically poor, need to be adequately compensated, for the use of their plant genetic resources, which have been conserved by farmers over the centuries, through the fair and equitable sharing of benefits arising out of the use of those resources.

The ITPGRFA provides for sharing of benefits arising from the use of plant genetic resources for food and agriculture, through information exchange, access to and the transfer of technology, and capacity-building. It also supports the implementation of a funding strategy to mobilize funds for activities, plans and programmes that help small farmers in developing countries. This funding strategy is partly comprised of monetary benefits paid under the multilateral system. To date, two project proposals from India have received financial support from the international Benefit-sharing Fund of the ITPGRFA in the second cycle of calls for proposals.

The ITPGRFA recognizes the enormous contributions that farmers and their communities have made and continue to make to the conservation and development of plant genetic resources. This is particularly important for local and indigenous communities and farmers in the centres of origin and crop diversity. The ITPGRFA has provisions on farmers' rights that include the protection of traditional knowledge, and the right to participate equitably in benefit-sharing and in national decision-making related to plant genetic resources. The governments themselves are responsible for implementing these rights. These provisions on farmers' rights in the ITPGRFA will help promote the global recognition of the important role played by farmers in crop improvement activities.

India has constantly emphasized the importance of establishing an effective benefit-sharing arrangement and funding strategy, such as that which ultimately formed an integral part of the ITPGRFA. Domestically, this is reflected in the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act of 2001, which recognizes and protects the rights of farmers in relation to their contribution to conserving, improving and making available plant genetic resources for the development of new plant varieties[3]. The PPV&FR Act strikes a balance between farmers' rights and breeders' rights.

The Revised National Policy for Farmers of 2006, highlights the benefits of the National Gene Fund and the Biodiversity Fund, as follows: 'Quite often, the conserved material of great value is the contribution of a community and not an individual. Therefore, the procedures adopted should be such that community contributions can be recognized and awarded suitably'[4]. Two major pieces of legislation – the PPV&FR Act and the Biological

[3] *The text of the PPV&FR Act is available at: http://agricoop.nic.in/PPV&FR%20Act,%202001.pdf.*

[4] *See: 1.4.6.2 of the Revised Draft National Policy for Farmers (2006). http://agricoop.nic.in/ncf/revised%20draft%20npf%20of%20ncf.pdf. The full text of the National Policy for Farmers, approved in 2007, is available at: http://agricoop.nic.in/NPF/npff2007.pdf.*

Diversity Act, 2002[5] – are in place for achieving some of the above aims. The implementation of these Acts could be strengthened by the development of detailed guidelines to promote the recognition of farmers' rights, and the rights of the farming community as a whole. Both the National Gene Fund and the Biodiversity Fund could be used to recognize and reward contributions made by farmers, and to support the revitalization of *in situ* on-farm conservation traditions of such communities. A start has already been made by the government with the establishment of the Plant Genome Saviour Community Award, which is awarded to communities of farmers by the Government of India.

The ITPGRFA promotes conservation and sustainable use

Plant genetic resources are essential for sustainable agriculture and food security. According to FAO, some 10,000 species of plants have been used as a source of food for humans throughout history. However, only about 120 cultivated species provide an estimated 90% of food requirements, while just four species – maize, wheat, rice and potato – provide about 60% of the dietary energy required by the human body. Of the myriad of varieties of those crops developed by farmers over the millennia, which form an important part of agricultural biodiversity, more than 75% have been lost over the past 100 years.

The ITPGRFA acknowledges that the conservation, exploration, collection, characterization, evaluation and documentation of plant genetic resources for food and agriculture are essential for meeting the goals of world food security, and for the sustainable development of agriculture, for present and future generations. This was also a major reason for India's ratification of the ITPGRFA.

Climate change poses additional serious risks to food security and the agricultural sector. Its expected impact is particularly fraught with danger for vulnerable populations and small farmers in developing countries. Any possible solutions for confronting the challenges of climate change must include options for mitigating climate change, as well as a firm commitment to the adaptation of agriculture through the conservation and sustainable use of genetic resources for food and agriculture.

India is both a primary and secondary centre of diversity for a number of crop species. *In-situ* conservation is, therefore, of great importance for maintaining and enhancing genetic diversity. The ratification of the ITPGRFA by India will help to address issues related to the conservation and sustainable use of plant genetic resources for national food security and agricultural development.

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[5] *The text of the Biological Diversity Act is available at: http://nbaindia.org/content/25/19/1/act.html.*

5 A note on the state of implementation of the multilateral system of access and benefit-sharing in India

R.C. Agrawal, Registrar-General, Protection of Plant Varieties & Farmers' Rights Authority, New Delhi.

P. Brahmi, Senior Scientist, National Bureau of Plant Genetic Resources, New Delhi.

P.L. Gautam, Chairperson, Protection of Plant Varieties & Farmers' Rights Authority, New Delhi.

INTRODUCTION

In India, the Biological Diversity Act, enacted in 2002, governs access to genetic resources for foreign nationals[1]. In 2002, India ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which creates the multilateral system of access and benefit-sharing (multilateral system)[2]. The ITPGRFA states that 'Contracting Parties shall take necessary legal and other appropriate measures' to provide facilitated access to plant genetic resources for food and agriculture included in the multilateral system. As such, there is a need to harmonize the provisions of the Biological Diversity Act (BDA), 2002 with India's commitment to provide facilitated access to plant genetic resources in the multilateral system, and more particularly, to enable providers within India to use the standard material transfer agreement (SMTA) when exchanging such resources.

Article 40 of the BDA 2002, allows 'the Central Government … in consultation with the National Biodiversity Authority, by notification in the Official Gazette, [to] declare that the provision of this Act shall not apply to any items, including biological resources normally traded as commodities.' Article 40 could be exercised to declare that the BDA shall not apply to Annex I materials in the multilateral system exchanged using the standard material transfer agreement (Arora, in this volume). Ultimately, policy developments of this nature will require coordinated actions by the National Biodiversity Authority, the Ministry of Agriculture, the Ministry of Environment and Forests, and other relevant organizations.

To move the process of implementing the ITPGRFA forward, India has established a Joint Working Group (JWG) on issues related to the ITPGRFA and other related treaties. The JWG is led by the Chairperson of the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Authority, with members from the Ministry of Agriculture; the Ministry of Environment and Forests; the Department of Legal Affairs; the Indian Council of Agricultural Research (ICAR); the National Biodiversity Authority; the Council of Scientific and Industrial Research; the Ministry of Commerce and Industry; the Department of Biotechnology; the National Seeds Association of India; and the Controller General of Patents, Designs and Trade Marks. The JWG has the following terms of reference:

- To develop and adopt long- and short-term measures on various technical and policy issues concerning the implementation of the ITPGRFA and other related treaties

1 *The text of the Biological Diversity Act is available at: http://nbaindia.org/content/25/19/1/act.html.*
2 *The text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

- To come to an agreement concerning the Government of India's position on various issues addressed at the meeting of the governing body of the ITPGRFA and subsidiary bodies
- To function as a think-tank for discussing issues pertaining to the ITPGRFA and other instruments on a regular basis
- To suggest future courses of action on ensuring compliance with regards to the implementation of the ITPGRFA

In addition, a National Advisory Board for the Management of Genetic Resources, chaired by Dr R.S. Paroda, from the Trust for Advancement of Agricultural Sciences (TAAS), and co-chaired by Dr S. Ayyappan, Director General of ICAR, has also been established for addressing issues related to the implementation of the ITPGRFA, and policies and procedures concerning the exchange of PGR in India. The aim of the board is to:

- Deliberate upon and recommend national policies on agrobiodiversity conservation, management and sustainable use
- Provide guidance for addressing related issues that emerge during international meetings of intergovernmental bodies
- Carry out occasional needs-based assessments, to evaluate and establish policy direction on direct issues concerning agrobiodiversity

The first meeting of this National Advisory Board was convened at the National Bureau of Plant Genetic Resources (NBPGR) in December 2011, to discuss issues related to the implementation of the ITPGRFA in India, and streamline policies and procedures for the exchange of PGR in India.

AUTHORITY FOR IMPLEMENTATION OF THE ITPGRFA IN INDIA

India has designated the Joint Secretary (Seeds) from the Department of Agriculture and Cooperation (DAC), of the Ministry of Agriculture, as the national focal point for the implementation of the various provisions of the ITPGRFA. The Joint Secretary coordinates various programmes and initiatives, in collaboration with the NBPGR, ICAR and the PPV&FR Authority. For the effective implementation of national obligations under the ITPGRFA in India, strong linkages have been established with the DAC.

The role of the National Bureau of Plant Genetic Resources

The NBPGR is mandated to conserve and manage PGRFA. It has been functioning de facto as a single-window system for the exchange of small samples of plant germplasm intended for research. Most requests for PGRFA from India and abroad are sent to the NBPGR, which responds to such requests by (i) arranging the material to be sent from regional or National Active Germplasm Sites; (ii) quarantining introduced material; and (iii) dispatching material to the indenter. The NBPGR uses the material transfer agreements for the acquisition of PGR both within and outside the country. After the implementation of the ITPGRFA in India, and the harmonization of its provisions through relevant national legislation, PGRFA will be exchanged through the NBPGR.

All exchanges of PGRFA must be routed through the NBPGR for two reasons: firstly, because *ex situ* germplasm is conserved and regenerated through the NBPGR; and secondly, because the Ministry of Agriculture has delegated the NBPGR with the unique task of overseeing all exports and imports of PGRFA in the country for research purposes, and for providing quarantine certification of material being exchanged.

PGRFA in the multilateral system under the ITPGRFA

The System-wide Information Network on Genetic Resources (SINGER) of the CGIAR Consortium of International Agricultural Research Centres demonstrated that about 10% of all material held by CGIAR genebanks is of Indian origin. Such material has already become a part of the multilateral system through the agreements between CGIAR Centres and the governing body of the ITPGRFA, which were signed in 2006. These materials are being supplied internationally, on a regular basis, by CGIAR Centres using the standard material transfer agreement (SMTA). This fact should be explicitly recognized by the governing body of the ITPGRFA, and CGIAR, as the meaningful and substantial contribution of countries towards the multilateral system of access and benefit-sharing.

Using the SMTA for transfers with CGIAR Centres

At present, the SMTA is used in India only for the exchange of germplasm with CGIAR Centres. As stated above, for other exchanges of germplasm, a different material transfer agreement is used. Tables 1 and 2 present details of the transfer of materials to India from CGIAR Centres using the SMTA, for research purposes, between 2009 and 2011, and of material acquired by CGIAR Centres from India.

Table 1. Materials transferred to India from CGIAR Centres, under the SMTA for research purposes, between 2009 and 2011

Centre	Crop	No. of samples
IRRI	Rice	24,935
CIMMYT	Maize	5,494
	Wheat	4,048
ICARDA	Wheat	302
	Barley	100
	Vetches	21
	Chickpea	668
	Lentil	686
	Fenugreek	13
CIP	Potato and sweet potato	244
IITA	Maize and bambara nut	249
Trial/nurseries from ICARDA, CIMMYT and IRRI		159,901

Source: NBPGR, New Delhi, India

Table 2. Number of samples acquired by CGIAR Centres from India, and number of SMTAs signed, between 2009 and 2011

Year of export	No. of samples exported	No. of SMTAs signed
2009	362	4
2010	81	4
2011	379	6
Total		

Source: NBPGR, New Delhi, India

A total of 296 SMTAs were signed to bring PGRFA into India from CGIAR Centres between 2009 and 2011 (93 in 2009; 101 in 2010; and 102 in 2011).

So far, the SMTA has not been used for any domestic transfers within India.

CONCLUSIONS

The international exchange of plant genetic materials, in support of research, breeding, and conservation, is one of the key requirements for sustainable agriculture and global food security. India has always been a forerunner in the formulation and implementation of the ITPGRFA; however, although it is already using the SMTA for the exchange of PGRFA with CGIAR Centres, guidelines are still being drafted for the confirmation of materials in the multilateral system, and for using it for exchanges with other providers and recipients. The Joint Working Group (JWG) and National Advisory Board for the Management of Genetic Resources are currently working towards the implementation of various provisions of the ITPGRFA, and are developing recommendations for future courses of action to ensure compliance.

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6 Fostering collaboration in the national implementation of the Convention on Biological Diversity and the International Treaty: challenges and opportunities

S. Arora, Director, Ministry of Environment and Forests, Government of India.

INTRODUCTION

Biodiversity encompasses the variety of all life on earth; it forms the web of life, of which we are an integral part, and upon which we so fully depend. India is well recognized as a mega-diverse country that is rich in biodiversity and associated traditional knowledge, which is found both coded, as in our ancient texts of Indian systems of medicine, and non-coded, as in oral undocumented traditions. Occupying just 2.4% of the world's landmass, India accounts for nearly 7% of global species recorded, while supporting almost 18% of human and 18% of cattle populations. The biotic pressure on our biodiversity is therefore immense. Over 45,000 species of plants and 91,000 species of animals have been recorded so far. The wide variety in physical features and climatic situations has resulted in a diversity of ecosystems, such as forests, grasslands, wetlands, mangroves, coral reefs and deserts. India is also an acknowledged centre of crop diversity, and harbours several wild varieties of crop relatives, mainly of rice, maize, millets and barley.

For India, the conservation of its biodiversity is crucial, not only because it provides a number of goods and services that are essential for human survival, but also because it is directly linked to sustaining the livelihoods, and improving the socio-economic conditions, of millions of our local people, thereby contributing to sustainable development and poverty alleviation.

THE CONVENTION ON BIOLOGICAL DIVERSITY

In the last few decades, biodiversity has come under increasing pressure on account of factors such as habitat fragmentation, development imperatives and, more recently, global warming. Global concern about the loss of biodiversity found expression in the Convention on Biological Diversity (CBD), which was adopted at the Rio Earth Summit in 1992.

The three objectives of the CBD are the conservation of biodiversity; the sustainable use of its components; and the fair and equitable sharing of benefits arising from the use of genetic resources. The CBD is the first comprehensive global agreement addressing all aspects relating to biodiversity. It is a framework agreement that provides for flexible, country-driven approaches to its implementation. The CBD has near universal membership, with 193 countries as parties. Prior to the adoption of the CBD, biological resources were considered to be the common heritage of humankind.

Recognizing the sovereign rights of states over their natural resources, the CBD stipulates that authority to determine access to their genetic resources rests with national governments and is subject to national legislation. The CBD thus sets out a new philosophy regarding the use of genetic resources. Article 15 of the CBD changed international intellectual property rights regarding genetic resources by shifting the right of control from the global commons to the sovereign state. Article 15(2) requires that countries '…endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions…' that contravene the purpose or objectives of the CBD[1]. Article 15 further mandates that countries obtaining genetic resources from external sources must secure 'prior informed consent' from the host country, and conduct the exchange on 'mutually agreed terms.' The CBD thus removed genetic resources from the commons.

As the global community prepared for the Rio+20 Summit, the CBD completed twenty years of its existence. There have been significant achievements under the aegis of the CBD in the last two decades, the most notable ones being: developing National Biodiversity Strategies and Action Plans (NBSAPs); raising awareness on the importance of and threats to biodiversity; mainstreaming the concept of biodiversity; and, more recently, adopting the Nagoya Protocol on access and benefit-sharing (ABS).

THE INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

As compared to the CBD, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a more recent development. The ITPGRFA was adopted in November 2001, as the progeny of the International Undertaking on Plant Genetic Resources for Food and Agriculture (International Undertaking)[2], and it entered into force in June 2004[3]. The genesis of the ITPGRFA can be traced back to Resolution 3 of the Nairobi Final Act[4] adopting the text of the CBD, and the subsequent revision of the International Undertaking, in harmony with the CBD, by the Conference of the Food and Agriculture Organization of the United Nations (FAO), in order to address the outstanding issue of *ex situ* collections not dealt with by the CBD, and the issue of farmers' rights. At that time, there was even a debate on whether the ITPGRFA adopted by the FAO Conference could be a protocol under the CBD itself.

The scope of the ITPGRFA covers all plant genetic resources for food and agriculture. However, within the ITPGRFA, the multilateral system of access and benefit-sharing (multilateral system) was established to deal with a subset of those resources, which are listed in Annex I of the ITPGRFA. Thirty-five food crops and 29 genera of forages are listed in Annex I. In addition, there are special provisions in the ITPGRFA for the genetic resources held by the CGIAR Consortium of International Agricultural Research Centres, including Annex I and non-Annex I resources. All CGIAR Centres have signed agreements with the governing body of the ITPGRFA, bringing resources referred to in Article 15.1(b) under the purview of the ITPGRFA, such that they are made available under the same conditions as the genetic resources included in Annex I.

The multilateral system recognizes that sovereign nations have rights over their own plant genetic resources. Under the multilateral system, contracting parties are given free access to plant genetic resources listed in Annex I of the ITPGRFA, for the purpose of research,

1 *The text of the CBD is available at: http://www.cbd.int/convention/text/.*
2 *The International Undertaking can be accessed at: http://www.fao.org/Ag/cgrfa/iu.htm.*
3 *The text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*
4 *The text of the Nairobi Final Act is available at: http://www.cbd.int/doc/handbook/cbd-hb-09-en.pdf.*

breeding and training for food and agriculture. Article 12.3 enumerates the conditions under which access shall be provided, and Article 12.4 mandates that facilitated access shall occur pursuant to a standard material transfer agreement (SMTA).

Article 13 of the ITPGRFA obliges the parties to share benefits arising from any material received under the SMTA. Article 13 covers technology access and transfers, and also encompasses genetically modified plant resources. Article 13.2(d) requires that any party deriving a benefit from the commercialization of any plant material accepted under an SMTA must pay an equitable share to an international fund.

THE RELATIONSHIP BETWEEN THE ITPGRFA AND THE CBD

The ITPGRFA is the outcome of the process to revise the International Undertaking to bring it in harmony with the CBD. Consequently, Article 1 of the ITPGRFA recognizes that its objectives will be attained by closely linking the ITPGRFA to FAO and the CBD.

The preamble to the ITPGRFA recognizes the mutually supportive nature of the relationship between the ITPGRFA and other international agreements. Moreover, the close links between the CBD and the ITPGRFA are enshrined in Article 19 of the ITPGRFA, which provides for close cooperation. In this regard, the functions of the governing body of the ITPGRFA shall be to:

- Establish and maintain cooperation with other relevant international organizations and treaty bodies, including in particular the Conference of the Parties to the CBD, on matters covered by the ITPGRFA
- Take note of relevant decisions of the Conference of the Parties to the CBD and other relevant international organizations and treaty bodies
- Inform, as appropriate, the Conference of the Parties to the CBD, and other relevant international organizations and treaty bodies, of matters regarding the implementation of the ITPGRFA

As regards the CBD, Article 22 stipulates that the provisions of the CBD shall not affect the rights and obligations of any contracting party deriving from any existing agreement, except where the exercise of those rights and obligations would cause serious damage or threat to biological diversity. Furthermore, the Conference of the Parties to the CBD has recognized the important role that the ITPGRFA will play, in harmony with the CBD, as has the FAO Conference in its call for cooperation between the two instruments and the Secretariat. Thus, there are clear institutional requirements and political calls for fostering close cooperation and working arrangements between the two instruments.

In essence, the CBD and the ITPGRFA have similar objectives; however, whereas the CBD has a more comprehensive scope, covering all biodiversity, the ITPGRFA covers only PGRFA. PGRFA is a subset of biodiversity as a whole, but PGRFA are distinct, at least in part, because they are developed through human use, require human intervention to be conserved, and are critical to human food security. While the CBD builds on the premise of national sovereignty over genetic resources to provide a basis for bilateral approaches to benefit-sharing, the ITPGRFA builds on national sovereignty to provide a basis for the multilateral system, and give access to the common pool of PGRFA included in Annex I of the ITPGRFA.

As far as domestic implementation is concerned, nearly all parties to the CBD have taken steps towards implementing the CBD at the national level, with almost 90% of countries having prepared National Biodiversity Strategies and Action Plans (NBSAPs). Having entered into force over a decade later, the implementation of the ITPGRFA at the domestic level is, understandably, still in its infancy.

Against this background, and with India's hosting of the eleventh Conference of the Parties to the CBD (COP-11), in Hyderabad in October 2012, this is an opportune time to analyse the challenges and opportunities, while attempting to foster collaboration between the national-level implementation of the CBD and the ITPGRFA.

POTENTIAL AREAS OF COLLABORATION

National Biodiversity Strategies and Action Plans

Parties to the CBD are required to fulfil two unqualified obligations: the preparation of NBSAPs, and the preparation of national reports. NBSAPs are the primary vehicles for the implementation of the CBD at the national level. The development of NBSAPs, in accordance with Article 6(a) of the CBD, is also essential for mainstreaming biodiversity across all sectors, as provided for in Article 6(b). The very fact that more than 90% of the CBD parties have adopted their NBSAPs or equivalent instruments, and nearly one third have also revised their NBSAP, is considered to be a step towards the domestic implementation of the CBD.

By 1999, five years after ratifying the CBD, and following an extensive consultative process, India prepared a National Policy and Macro-level Action Strategy on Biodiversity, elaborating on existing policies and programmes, and identifying gaps and further necessary actions. Thereafter, India implemented an NBSAP project, with funding from the Global Environment Facility, which has been hailed the world over as the most participatory and decentralized biodiversity policy planning exercise. Based on the technical report of the NBSAP project, the 1999 document was revised after inter-ministerial consultations, becoming the National Biodiversity Action Plan (NBAP), which was approved by the Cabinet in 2008. Thus, India has already prepared two generations of NBSAPs.

The tenth Conference of the Parties to the CBD (COP-10), which was held in October 2010, through decision X/2, adopted the Strategic Plan for Biodiversity 2011–20 (strategic plan), with 20 Aichi targets under five strategic goals. This strategic plan is now the agreed framework on biodiversity for all conventions and stakeholders. COP-10 urged parties to develop national targets, using the strategic plan and its Aichi targets as a flexible framework in accordance with their national priorities and capacities, and taking into account the resources provided; and report back to COP-11. Parties were also urged to review and, as appropriate, update and revise their NBSAPs in line with the strategic plan, including by integrating national targets into the NBSAPs; and to report back to COP-11 or COP-12. Parties were urged to take into account the synergies between the biodiversity-related conventions in a manner consistent with their respective mandates.

Among all the biodiversity-related treaties, it is only the CBD that obliges parties to prepare NBSAPs as mechanisms for national planning. Moreover, the CBD may be considered an overarching umbrella treaty, broadly encompassing the objectives of other biodiversity conventions. Hence, the NBSAPs are certainly appropriate tools for the coordinated implementation of biodiversity-related agreements, including the ITPGRFA.

Like the NBSAPs of many other countries, India's present NBSAP implicitly covers the ITPGRFA through provisions for the conservation and sustainable use of agrobiodiversity. Furthermore, the Ministry of Agriculture has been identified as the lead coordinating agency for some of the action points, and was associated agency for many of the action points in the NBAP of 2008. This is despite the fact that India's first generation NBSAP was finalized in 1999, thereby predating the ITPGRFA.

The Aichi biodiversity targets, which were adopted by COP-10, are relevant to all biodiversity-related conventions. For example, in the context of the ITPGRFA, the relevant targets are targets 7, 13, 14 and 18. In pursuance of the COP-10 decision, India has initiated the exercise of preparing national targets in line with the Aichi targets, in consultation with the ministries or departments concerned. Inter-ministerial coordination is being facilitated through the Planning Commission, at the request of the Ministry of Environment and Forests.

Since India's second generation NBSAP was launched fairly recently, no revisions are expected other than to update the NBSAP to integrate national targets developed pursuant to the consultative process. This, therefore, provides a good opportunity for the national focal point of the ITPGRFA to get involved in the process of developing national targets, and updating the NBSAP.

Making space, through the Biological Diversity Act of 2002, for the multilateral system

India enacted a comprehensive Biological Diversity Act in 2002, and issued the Biological Diversity Rules in 2004[5], to implement the provisions of the CBD, including those relating to access and benefit-sharing (ABS). India was one of the first countries to enact such legislation. Since the Act was issued almost eight years before the Nagoya Protocol on ABS, which was adopted by COP-10 following arduous negotiations, it can be considered that India has some experience in the implementation of ABS at national level. The Biological Diversity Act (BDA) is progressive legislation that has the potential to significantly improve biodiversity conservation in the country. There are a number of provisions in the Act that are relevant to the domestic implementation of the ITPGRFA. Section 6(3) and (4) of the Act provide for exemptions from the application of the Act for applicants for intellectual property rights under any laws in India (including the Protection of Plant Varieties and Farmers' Rights Act), thereby harmonizing the BDA with national IPR legislation. Furthermore, in accordance with Section 8(4)(c), representatives of the Department of Agriculture and Cooperation (DAC) and the Department of Agricultural Research and Education (DARE) are ex-officio members of the National Biodiversity Authority (NBA). Recognizing the special status and requirements of agrobiodiversity, Section 13(1) mandates the NBA to set up a committee to deal with agrobiodiversity issues.

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5 *The texts of the Biological Diversity Act and the Biological Diversity Rules are available at: http://nbaindia.org/content/25/19/1/act.html.*

As far as the multilateral system of the ITPGRFA is concerned, national ABS laws that have been developed recently (for example, in Norway and Peru) provide for special treatment of Annex I crops of the ITPGRFA. However, since India's Biological Diversity Act predates the ITPGRFA, there is no such provision. Notwithstanding this, there is a general exemption clause, Article 40, which states that 'the Central Government may, in consultation with the National Biodiversity Authority, by notification in the Official Gazette, declare that the provisions of this Act shall not apply to any items, including biological resources normally traded as commodities'. So far, this clause has been made use of only to exempt 'biological resources that are 'normally traded as commodities'. In the event that the Ministry of Agriculture develops a domestic mechanism for ensuring ABS for Annex I crops of the ITPGRFA, there is the possibility to exempt such crops from the provisions of the Biological Diversity Act, with qualifiers as appropriate. This would provide the requisite legal space for the implementation of the multilateral system. It merits mention here that PGRFA other than Annex I crops would still need to be covered by the Biological Diversity Act in the context of ABS. On the issue of traditional knowledge, Section 36(5) of the Biological Diversity Act is relevant in the context of the provisions on farmers' rights listed in the ITPGRFA.

The Nagoya Protocol on access and benefit-sharing and the multilateral system

Paragraph 4 of Article 4 of the Nagoya Protocol, concerning relationships with international agreements and instruments, is highly relevant for understanding the role of the Nagoya Protocol in international law on ABS; it states that the 'Protocol is the instrument for the implementation of the access and benefit-sharing provisions of the Convention,' thereby emphasizing its central role in ABS governance[6]. The paragraph goes on to elaborate the relationship of the Nagoya Protocol with specialized ABS instruments. While there is no explicit reference to the ITPGRFA in this paragraph, to date the only specialized instrument on ABS is the ITPGRFA. Despite strong attempts by many countries during negotiations to explicitly exclude the ITPGRFA from the scope of the Nagoya Protocol, this was not agreed. The provision that was agreed provides that the Nagoya Protocol would not apply to the specific genetic resources covered by and for the purpose of the specialized instrument on ABS, provided the instrument is consistent with, and does not run counter to, the objectives of this Protocol.

The scope of access and benefit-sharing under the ITPGRFA applies to the genetic resources included in Annex I in the multilateral system, and to the non-Annex I genetic resources held in collections of CGIAR Centres, and other international institutions that made agreements with the governing body of the ITPGRFA. Hence paragraph 4(4) can be interpreted to exclude these genetic resources from the purview of the Nagoya Protocol.

The national focal point of the ITPGRFA must consider this provision when developing the mechanism for the national implementation of the multilateral system of the ITPGRFA.

CONCLUSIONS

The CBD, the ITPGRFA and the Nagoya Protocol are the global international agreements that currently provide access and benefit-sharing arrangements for genetic resources. As such, their relationship is of central importance in implementing national access and

6 *The text of the Nagoya Protocol is available at: http://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf.*

benefit-sharing mechanisms. All parties to the ITPGRFA are currently parties to the CBD, while not all parties to the CBD are parties to the ITPGRFA; however, the situation is dynamic and could change.

The ITPGRFA came into force subsequent to the CBD, and is arguably a form of *lex specialis*. It is recognized that the ITPGRFA should be implemented in harmony with, and mutually supportive of the CBD, and that its objectives can only be achieved if the two instruments work closely with each other.

In the current situation, where parties to the CBD are also contracting parties to the ITPGRFA, in accordance with Article 30 of the Vienna Convention on the application of successive treaties relating to the same matter, the latter (the ITPGRFA) would prevail, to the extent of the scope of the ITPGRFA.

Despite the apparent differences in the design and application of the ITPGRFA vis-à-vis the CBD, with overlapping obligations, there are opportunities for collaborating and coordinating their implementation at the national level, primarily through the NBSAP and the Biological Diversity Act. While the implementation of the ITPGRFA at the national level has generally been slow so far, it could be energized by fostering linkages with the existing mechanisms and processes that have already been developed or put in place for the implementation of the CBD. This would not only prevent the duplication of efforts and resources, but could also lead to the cost-effect implementation of the two instruments, and promote the consideration of biodiversity in a broader development policy context during the United Nations Decade on Biodiversity, 2011–2020.

7 Who exchanges plant genetic resources for food and agriculture in India and for what purposes?

J.S. Sandhu, Assistant Director General (Seed), Indian Council of Agricultural Research, New Delhi.

V. Tyagi, Senior Scientist, National Bureau of Plant Genetic Resources, New Delhi.

S. Sandhu, Plant Breeder, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana.

INTRODUCTION

Plant genetic resources for food and agriculture (PGRFA) are the biological basis of world food security and, directly or indirectly, support the livelihoods of every person on earth. PGRFA encompass a diversity of genetic material in traditional crop plant varieties and modern cultivars, as well as crop wild relatives and other wild plant species used as food. Over the last 10,000 years, plant domestication produced numerous landrace populations that served as the foundation materials for further genetic improvement, through more recent selective breeding carried out over the last 150 years. Domestication and crop improvement entailed several genetic bottlenecks that reduced the levels of genetic diversity in modern crops. In fact, most contemporary crop varieties descend from a relatively small number of landraces. A significant portion of beneficial/superior alleles were not passed down during the processes of evolution and domestication. They are reservoirs of genetic adaptability to buffer against potentially harmful environmental and economic change. It has become increasingly clear over the last few decades that meeting the food needs of the world's growing population depends, to a large extent, on the conservation and use of the diverse plant genetic resources available worldwide.

During the last three decades of the twentieth century, rapid progress was made in the field of agriculture, including the collection, conservation, exchange and sustainable utilization of plant genetic resources. The exchange of PGRFA and their utilization is a continuous process, which has benefited agriculture across the globe. At the national level, the National Bureau of Plant Genetic Resources (NBPGR) is the nodal institution for the management of PGR under the umbrella of the Indian Council of Agricultural Research (ICAR) in New Delhi. The NBPGR has developed a very strong Indian Plant Germplasm Management System, which operates in joint partnership with other organizations. The system has contributed immensely towards safeguarding indigenous crop genetic resources, and exchanging plant genetic resources with other countries for enhancing agricultural production and productivity in the country. The NBPGR is also serving the needs of researchers for various crop improvement programmes through supplying the germplasm desired from the National Genebank at the NBPGR, and from active collections maintained at NBPGR regional stations in different agro-climatic zones of the country. Crop-based institutes affiliated with ICAR have been designated as National Active Germplasm Sites (NAGSs) with the responsibility to collect, conserve, evaluate, document and distribute germplasm to users within the country. NAGSs are effective partners in collaborating with the NBPGR for meeting the requirements of researchers in the country. The primary objective of this paper is to learn more about the use and distribution of germplasm accessions, which may help to identify areas of constraint, and subsequently, promote the development of policies to enhance germplasm exchange.

CURRENT EXCHANGE PROCEDURE

Plant genetic resources for food and agriculture are exchanged within India, and between India and other countries and international organizations. In order to access seed or planting material from outside India, the germplasm must be introduced/imported following the Plant Quarantine (Regulation of Import into India) Order, 2003[1]. The Director of the NBPGR is authorized to issue such import permits for the purposes of research (Datta et al, in this volume)

However, much of the germplasm required by the large number of scientists engaged in research in India is available in the country. If the desired materials are available through the NBPGR, they are collected and forwarded to the indentor, or else the requests are forwarded to various sources in India, including NAGSs, and the material thus procured is forwarded to the indentor under a material transfer agreement.

Exchange of PGRFA within India

Access at national level is based on the provisions of the Biological Diversity Act (BDA) of 2002, and the Biological Diversity Rules of 2004[2]. Requests for supplies of small quantities of germplasm, for research purposes only, are considered by the Director of the NBPGR. Indentors must submit requests using requisition forms for the supply of seed or planting materials. The NBPGR provides germplasm maintained in a network of regional stations and NAGSs, where the active collections are held. The material is always transferred under a material transfer agreement, though rarely using the standard material transfer agreement (SMTA) for use in the multilateral system of access and benefit-sharing created by the International Treaty on Plant Genetic Resources for Food and Agriculture (Agrawal et al; Datta et al, in this volume).

The NBPGR meets 85–90% of the requests with materials from its headquarters in New Delhi and from regional stations at Akola, Cuttack, Bhowali, Ranchi, Jodhpur, Hyderabad, Shimla, Srinagar, Shillong and Thrissur. Based on the frequency of the requests it received, and on the number of accessions supplied during the period 2001–2010, the authors ranked the crops on a scale of 1–25 (Tables 1 and 2). A total of 2,076 requests were registered, whilst a total of 128,658 samples of crops belonging to 221 genera were supplied for the same period. Previously, seed material was supplied by the NBPGR to private sector companies based on their specific scientific needs, and this material was not subject to access and benefit-sharing regulations. However, the BDA, 2002 (and Rules, 2004), requires a range of private companies to attain permission, under the Act, before gaining access to genetic resources in the country. In particular, Article 3.2 of the BDA requires that, 'a body corporate, association or organization – i) not incorporated or registered in India; or ii) incorporated or registered in India under any law for the time being in force which has any non-Indian participation in its share capital or management' shall not obtain a biological resource in India without approval from the National Biodiversity Authority. As a result, distribution to such companies has decreased. The types of users who currently access the germplasm are mainly plant breeders from the public sector, followed by students engaged in research activities (Figure 1).

1 *See: http://dbtbiosafety.nic.in/act/Plant%20Quarantine%20_order_2003.pdf.*

2 *The texts of the Biological Diversity Act and the Biological Diversity Rules are available at: http://nbaindia.org/content/25/19/1/act.html.*

Table 1: Top 25 crops requested, based on the frequency of requests received (2001–2010)[3]

Crop	No. of requests registered	Rank
Rice	134	1
Okra	89	2
Chilli	81	3
Tomato	80	4
Wheat	73	5
Mustard	57	6
Cowpea	55	7
French bean / kidney bean	55	7
Brinjal	53	8
Sesame	49	9
Mung bean	44	10
Pea	42	11
Soybean	41	12
Bitter gourd	38	13
Pigeonpea	36	14
Banana	35	15
Horse gram	33	16
Guar/ cluster bean	32	17
Maize	32	18
Lentil	31	19
Urd bean/Urid bean	30	20
Chickpea	26	21
Pearl millet	22	22
Onion	21	23
Sunflower	19	24
Cucumber	18	25

Although the NBPGR conserves a vast repository of novel genes that may be utilized in breeding new crop varieties, most requests are not very specific in nature. On the basis of the requests submitted, access is mainly requested for carrying out biochemical analysis, molecular characterization, phyto-chemical evaluation, screening, evaluation, breeding and for grafting studies.

3 *Data in Tables 1 and 2 were assembled by the authors from the records/ledger books of the Germplasm Exchange Unit. The NBPGR receives a large number of requests and they are serially registered in ledger books. All ledgers are kept as records in the NBPGR.*

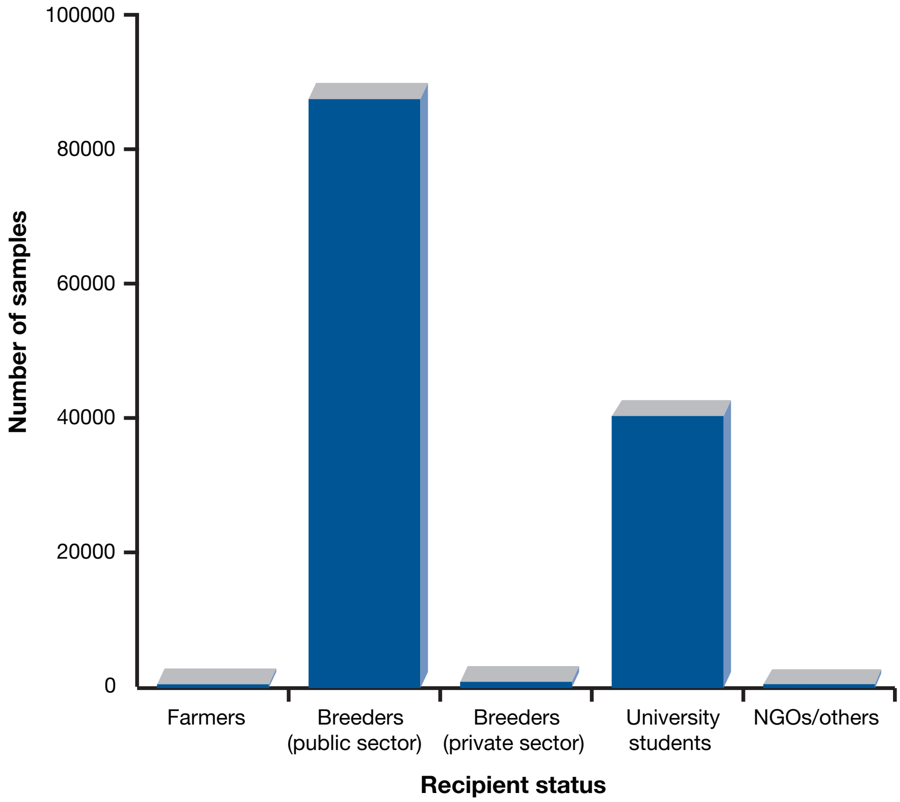
Table 2: Top 25 crops supplied, based on the number of accessions supplied (2001–2010)

Crop	No. of samples supplied	Rank
Wheat	28,966	1
Rice	25,017	2
Finger millet	7,204	3
Guar/ cluster bean	4,372	4
Brinjal	2,306	5
Pigeonpea	2,219	6
Okra	2,020	7
Tomato	1,859	8
Mung bean/ green gram	1,797	9
Barley	1,352	10
Chilli/sweet pepper	1,221	11
Rape seed mustard	1,023	12
Pea/ sweet pea	1,007	13
Sesame	854	14
Urd bean /Urid bean	841	15
Cowpea	799	16
Lentil	798	17
Mustard	639	18
Horse gram /Kulthi	619	19
Moth bean	615	20
Onion	612	21
Maize	609	22
Banana	559	23
Bottle gourd	487	24
French bean / kidney bean	392	25

Exchange of PGRFA accessed from outside India

Germplasm is introduced/imported into India following the regulations of the Plant Quarantine (Regulation of Import into India) Order of 2003, as mentioned above. For this paper, the authors analysed the number of applications received over the period 2001–2010, for introducing/importing desired plant genetic resources into India. The major stakeholders requesting germplasm from other countries were grouped as ICAR institutes; state agricultural universities (SAUs); CGIAR Centres within India; private seed companies; non-governmental organizations (NGOs); and other traditional universities (Figure 2). The applications submitted for importing germplasm show that breeders in

Figure 1: Germplasm distribution from the NBPGR to different recipient groups (2001–2010)



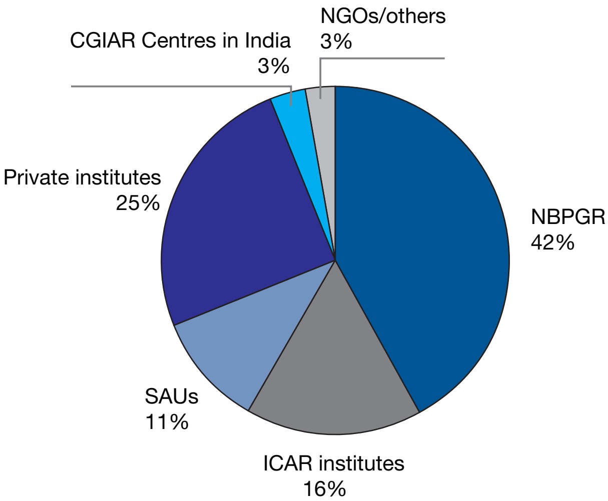
Source: NBPGR

public seed enterprises are interested in wild species/wild relatives, as these constitute diverse germplasm for genetic base broadening. However, private seed companies are mainly concerned with importing maize hybrids. The NBPGR is continuously making efforts to introduce unique germplasm, which generally includes registered germplasm, germplasm/cultivars resistant to various biotic and biotic stresses, and other value added traits.

A similar study to that carried out by the authors was conducted by Curan et al (2010) on plant genetic resources and germplasm use in India; their study showed that the most sought after traits are high yield, drought tolerance and disease resistance. The study was also expanded to include breeders' approaches to acquiring germplasm and accessing information about germplasm, and benefits associated with germplasm use.

The plant genetic resources provided were used mostly in crop improvement programmes, for increasing diversity within species, and extending the spectra of cultivated species. Crop improvement programmes are completely dependent on the diversity of materials that are available to them, which mainly consists of local landraces, old primitive cultivars, exotic introductions, selected breeding materials and genetic stocks with specified characteristics. All crop improvement centres place varying degrees of emphasis on the collection, evaluation and maintenance of germplasm stocks. However, due to resource constraints, the evaluation of collected material is often restricted to specified objectives. And maintenance, particularly over a long period, is not properly addressed.

Figure 2: Percentage of requests for importing germplasm utilized in crop improvement programmes including indents (requests) placed by the NBPGR, New Delhi (2001–2010)



Source: NBPGR

POLICIES AND RESTRICTIONS INFLUENCING THE EXCHANGE AND USE OF PGRFA

The constraints that limit the exchange and use of PGRFA, either by breeders, or by genebanks, are also of major concern and need proper attention.

In a survey carried out by the NBPGR in 2001, plant breeders in the Indian National Agricultural Research System highlighted the following major constraints as limiting the exchange and use of PGRFA:

- Procurement procedures, policies and systems
- Lack of information for breeders on the type and availability of germplasm held in genebanks
- Insufficient quantity of germplasm for targeted crops
- Characterization and evaluation data are not available
- Complete passport data are not available
- Delays in receiving responses to applications for germplasm and, consequently, in obtaining germplasm
- Breeders do not actively request germplasm from genebank curators
- The process of introducing desirable materials from other countries is faster and less expensive than that of obtaining germplasm from Indian institutes
- Requirement to use an MTA/SMTA to distribute the germplasm
- The need to fulfil the specific conditions applied to distributed germplasm, such as reporting feedback on uses, supplying multiplied seed of the sample to the provider, and acknowledging the provider of the germplasm

The use of germplasm may be promoted through online catalogues. In the past, crop catalogues with passport information and characterization data were published mainly for exchange of information and seed material with breeders. Now, the NBPGR has developed a database for germplasm conserved in the National Genebank, which is currently being validated. The database has 30 data fields for each accession in the genebank related to passport, characterization, evaluation and conservation status. However, in the current regime of international laws and intellectual property rights, decisions must continually be made concerning what kind of information may be placed in the public domain, with a view to promoting the conservation of plant genetic resources through use by both the public and private sectors.

Constraints on the enhanced use of plant genetic resources for food and agriculture

The Food and Agriculture Organization of the United Nations (FAO) has estimated that about three-quarters of the original varieties of agricultural crops have been lost from farmers' fields since the 1900s, and this trend has accelerated over the last half century. Since the advent of the Green Revolution in the 1960s, farmers have increasingly abandoned their traditional landraces of wheat, rice and other crops, in favour of high yielding, new seeds. By the 1990s, the adoption of modern varieties of wheat, rice and maize in developing countries had reached 90%, 70% and 60%, respectively (Wood et al, 2000). In 1949, farmers in China were growing nearly 10,000 wheat varieties; by the 1970s, only about 1,000 varieties remained in use. Today, wheat landraces are extensively cultivated in isolated patches of the drier production zones of west Asia, north Africa and in the highlands of Ethiopia. A wide range of crops, from broccoli to sugarcane, are following a similar trend. In the United States, less than five hybrid broccoli plants account for 80% to 90% of the broccoli crop, with just one hybrid, 'Marathon,' accounting for more than 50% of acreage. Most sugarcane cultivars in the world today are the result of crosses made with only a few clones that were selected in the late 1800s and early 1900s in India and Java. This narrow genetic base puts sugarcane cultivation at risk from several diseases, including rust, smut, and eyespot, and has resulted in a yield plateau.

The Report on the State of the World's Plant Genetic Resources for Food and Agriculture was prepared for the International Technical Conference on Plant Genetic Resources, held in Leipzig, Germany, in June 1996, based on information supplied by different countries. The report lists several constraints hindering the greater use of plant genetic resources, which include a lack of information on materials available *in situ*; lack of information on the materials conserved; difficulty in accessing collections; difficulty and expense of introducing genetic diversity into breeders' adapted lines; lack of availability of landraces for direct use; unsustainable use of wild, underutilized species; limited range of species addressed; and restrictions on variety release and seed distribution. A number of practices may be used to enhance the utilization of plant genetic resources, including the rational organization of base, active and working collections of germplasm; strengthening of documentation and communication systems; mutually agreed arrangements, including legal instruments where appropriate; greater collaboration between genebanks and breeders through strong national programmes; improvement programmes for minor staples and other underutilized species; provision of landraces to farmers by genebanks for multiplication and distribution; and decentralized breeding, including participatory approaches. The development of core collections and extensive phenotypic characterization based on defined descriptors can ease the difficulty of handling large collections. Pre-breeding/genetic enhancement programmes, including those aimed at broadening the base of adapted lines, are considered to be a necessary first step in the use of diversity arising from wild relatives and other unimproved materials. Pre-breeding is a vital link between the conservation and use of plant genetic resources. It involves all activities designed to identify desirable characteristics and/or genes from unadapted materials that cannot be used directly in breeding populations, and to transfer these traits to an intermediate set of materials that breeders can use further in producing new varieties for farmers. It is a long-term activity involving high costs. As illustrated in Figure 1, the main users of germplasm are public research institutes and universities. Private sector breeders with targets to reap immediate benefits cannot generally afford to undertake such work. Despite the current constraints on pre-breeding programmes, they are essential for making genebank collections more usable, and as such should be a major component of national agriculture programmes. Furthermore, national funding agencies should provide grants to projects that focus on pre-breeding and genetic enhancement. Investment in pre-breeding will help to maintain the link between the conservation of diverse crop genetic resources and the modern breeding programmes. These programmes aim to reduce genetic uniformity in crops through the introduction of a wider base of diversity, as well as to increase yields, resistance to pests and diseases, and other quality traits.

In the field of genetic enhancement, Punjab Agricultural University (PAU) has taken a tremendous leap forward, through wide hybridization and alien introgression in chickpea, wheat and rice. Among all the state agricultural universities and the national institutes, PAU has the largest collection of wild species of wheat and rice, and is a gold mine for more than 1,200 accessions of wild species of wheat, and more than 2,400 accessions of rice. The university has analysed genetic diversity in the wild progenitor species of wheat, *Aegilops tauschii* and *Ae. Speltoides*, with simple sequence repeat (SSR) markers, and has identified and used genetically diverse accessions with desirable traits in a crossing programme. In addition, more than 20 genes with resistance to pests and diseases, and comprising quality and productivity related traits, have been transferred from different wild species, such as *T. monococcum*, *T. boeoticum*, *Ae. tauschii*, *Ae. ovata*, *Ae. triuncialis*, *Ae. umbellulata*, *Ae. caudata* and *Ae. Variabilis*, to cultivated wheat varieties. Twenty genes with resistance to diseases including leaf rust, stripe rust, powdery mildew, karnal bunt, and CCN, have been transferred from ten different sources to the highly susceptible bread wheat cultivar, WL711. In chickpea, a large number of accessions of cultivated species and wild species have been evaluated for a number of traits, including disease resistance and cold tolerance. These trait specific genotypes were involved in the hybridization and development of a number of superior lines. Lines resistant to ascochyta blight (*Ascochyta rabiei*) and botrytis grey mould (*Botrytis cinerea*) were also developed through wide hybridization.

A set of 300 accessions belonging to six A-genome species of *Oryza* were analysed with microsatellite markers; levels of genetic diversity within each species were assayed. A selected set of five to ten diverse accessions from each of the six A-genome species *O. glaberrima*, *O. barthii*, *O. nivara*, *O. rufipogon*, *O. meridionalis*, and *O. glumaepatula*, were used for the identification, mapping and transfer of novel alleles for productivity-related, quantitative trait loci (QTL) from these species, using the advanced backcross QTL strategy. A set of 2,000 introgression lines with alien genomes from more than 30 accessions of five different species, have been generated and are being evaluated for their agronomic performance. A large number of wild species accessions of rice have also been screened for bacterial leaf blight (BB) resistance, and novel sources of resistance have been identified. Three new BB resistant genes – two from *O. nivara*, and one each from *O. glaberrima* and *O. barthii* – have been mapped and transferred to cultivated rice *O. sativa*. One of these genes was identified as *Xa38*. These genes have been tagged and are being used for marker assisted selection (MAS). Considering PAU as a role model, other SAUs should make genetic enhancement and the effective utilization of germplasm resources a major research component of their breeding programmes.

Conservation and use of landraces

Given the immediate need to address the issue of food security, the green revolution replacement model of agricultural development, in which landraces are displaced by the so-called high yielding and fertilizer responsive modern varieties, is still being emphasized. Landrace conservation programmes need to be developed using community-based approaches. In Nepal, about 53% of farming households continue to grow both modern varieties and landraces (Joshi and Bauer, 2006). Farmers generally grow high yielding modern varieties for sale, and landraces for household consumption. Their selection of these varieties is clearly shaped in part by market demand, and land and soil heterogeneity, but it is also influenced by the consumption preferences of their families. The main reason why such a small area is dedicated to the cultivation of landraces is because their productivity is low and the prices are not high enough to compensate for their lower productivity in comparison to the modern rice varieties. Landraces have been surviving in farmers' fields precisely because they have specific characteristics that modern varieties lack. Landraces with unique, useful genes are hard to replace with modern rice varieties with the ability to survive and perform well *in situ*. Koraput district in Odisha is known for its rich biodiversity and natural resources, of which rice landraces occupy a prime position. Scientists at the M.S. Swaminathan Research Foundation (MSSRF), together with tribal farmers, surveyed a number of plots in which landraces of crops, including rice, were planted. The major problem encountered was the low yields of those rice landraces that farmers preferred for consumption. The problems were exacerbated by the lack of availability of quality seeds and financial support required for their proper cultivation (Pant, 2010).

The loss of crop wild relatives has profound implications for agriculture. Plant breeders and farmers depend on the wild relatives of crops as an essential source of genes. For example, wild wheat varieties recently provided domesticated varieties with genes resistant to fungal diseases, drought, cold, and heat. A single sample of wild rice from central India provided resistance to two of Asia's main rice diseases. As compared to modern wheat varieties, landraces, with relatively higher biomass, may not invest in larger root dry mass, but rather in increased partitioning of root mass to deeper soil profiles, increased ability to extract moisture from those depths, and higher transpiration efficiency. Facultative growth habit is a unique characteristic of some wheat landraces; it provides flexibility of sowing either in the fall as a winter crop, or in the spring, after the failure of the crop to overwinter.

Utilization of minor crops

Viewed from a global perspective, a remarkably small number of cereal crops provide a large proportion of total food requirements. However, when food energy supplies are analysed on a sub-regional level, a much greater number and type of crops emerge as significant. These include sorghum, millet, potatoes, sugarcane and sugar beet, soybean, sweet potatoes, beans, and bananas. Cassava, for example, supplies over half of the plant-derived energy for Central Africa, though it contributes only 1.6% globally. While many of these crops provide the main staples for millions of the world's poorer people, they receive much less attention or investment in terms of research and development. As shown in Table 2, out of 128,658 samples supplied on demand by the NBPGR, India, about 42% comprised accessions of just two crops – wheat and rice – while the remaining 58% addressed 23 crops.

Identification and access to allelic variation that affects the plant phenotype is of the utmost importance for the utilization of genetic resources, such as in plant variety development. Considering the huge numbers of accessions that are held collectively by genebanks, genetic resources collections harbour a wealth of undisclosed allelic variants. The challenge is how to unlock this variation. Allele mining is a promising approach to detecting naturally occurring allelic variation in candidate genes that control key agronomic traits of potential use in crop improvement programmes.

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8 Major patterns of germplasm flow within, into and out of India

S.K. Datta, Deputy Director General (Crop Science), Indian Council of Agricultural Research (ICAR), Krishi Bhawan, New Delhi.

A. Lal, Principal Scientist & Head, Germplasm Exchange Unit, NBPGR, New Delhi.

V. Tyagi, Senior Scientist, Germplasm Exchange Unit, NBPGR, New Delhi.

INTRODUCTION

The flow of germplasm offers enormous opportunities for better economic growth; food and nutritional security; enhanced stability; and a sustainable environment. The continuous flow of genetic resources is necessary for developing varieties of increased quality, quantity and resistance to various pests and diseases. There is undeniable interdependence between countries and continents for these genetic resources, and even biodiversity rich regions depend on crops originating from other countries for more than 50% of their food production (Cooper et al, 1994). This interdependence plays a very important role in the international collection and flow of germplasm into, within and out of the country.

The National Bureau of Plant Genetic Resources (NBPGR) is the nodal institution in India concerning germplasm exchange. The NBPGR introduces/imports plant genetic resources for research and experimental purposes into India, based on specific requests from the users in the country, and also at the initiative of its own scientists. These resources are imported into India from other countries, and from international agricultural research centres and other agencies with which the country has joint protocols/memoranda of understanding (MoUs), on a reciprocal basis. The NBPGR has linkages with over 115 countries. Once properly introduced into India, following all the relevant policies, the NBPGR distributes the materials within the country.

In the past, plant genetic resources for food and agriculture (PGRFA) were transferred internationally without much regulated restrictions. However, the scenario has changed from free flow to regulated access of genetic resources, as a result of national and international agreements, intellectual property rights (IPRs), and the expanded scope of these agreements to include plant varieties. For a regulated flow of genetic resources, developing countries need to understand the implications of IPRs relevant to genetic resources.

GERMPLASM FLOWS INTO INDIA

Several countries have established plant introduction services and organizations for regulating the in-flow (import) and out-flow (export) of germplasm. The national plant introduction service in most countries has a number of features in common, which facilitate their efficient operation, e.g:

- The service usually forms part of the Department of Agriculture, or a major research organization, and hence is able to draw upon extensive resources in carrying out its work

- It has either direct responsibility for plant quarantine, or works in close collaboration with the quarantine authority
- It has good testing facilities in all the major climatic zones of the country concerned
- It maintains records of introduced plants, usually including plants introduced by other agencies, and is thus able to ensure that national requirements are met without unnecessary duplication
- It provides a contact point for international collaboration through the Food and Agriculture Organization of the United Nations (FAO) and other agencies
- By maintaining extensive collections, and by establishing close collaboration with its counterparts abroad, the plant introduction service is able to provide plant material needed by specialists across the country

In India, the Centralized Plant Introduction Agency, funded by the Indian Council of Agricultural Research (ICAR), was initiated in 1946 in the Botany Division of the Indian Agricultural Research Institute (IARI). In 1956, under the second, five-year plan, the agency was expanded to form the Plant Introduction and Exploration Organization. In 1961, it was further upgraded to an independent division of Plant Introduction at IARI in New Delhi. In 1976, the division morphed into an independent institute, the National Bureau of Plant Introduction (NBPI); and in 1977, it was renamed the National Bureau of Plant Genetic Resources (NBPGR). Today, the NBPGR is responsible for the introduction and maintenance of germplasm of agricultural and horticultural plants.

In India, there is a single-window system for the exchange of small samples of plant germplasm (including transgenics) intended for research, and the NBPGR is the nodal institution responsible for overseeing this system. It regulates the import of seeds and planting material for research under the provisions of the Plant Quarantine (Regulation of Import into India) Order, 2003[1], and of the Destructive Insects and Pests (DIP) Act of 1914[2]. Plant introductions include germplasm, elite strains, improved varieties, genetic stocks and related species from various parts of the world. In order to prevent the introduction and spread of pests associated with plant genetic resources, and to ensure that only pest-free material is supplied to the indentors, strict plant quarantine protocol is followed, including post-entry quarantine. The NBPGR has been empowered by the Ministry of Agriculture to undertake the quarantine processing of all germplasm and research material, including transgenic material under exchange for both public and private sectors.

PROCEDURES FOR CONTROLLING GERMPLASM FLOW INTO INDIA FOR RESEARCH PURPOSES

The Plant Quarantine (PQ) Order of 2003 defines ‘germplasm’ as whole plants, or parts of plants and their propagules, which include seeds, vegetative parts, tissue cultures, cell cultures, genes and DNA-based sequences that are held in a repository, or collected from the wild as the case may be; and which are utilized in genetic studies or plant breeding programmes for crop improvement.

As per the New Policy on Seed Development (1989)[3], and the PQ Order of 2003, the Government of India has made it obligatory for all plant breeders and researchers

1 *The text of the Order is available at: http://dbtbiosafety.nic.in/act/Plant%20Quarantine%20_order_2003.*
2 *The text of the Act is available at: http://agricoop.nic.in/dtpact.htm.*
3 *The Policy can be accessed at: http://seednet.gov.in/Material/NEW_POLICY_NPSD.pdf.*

intending to receive seed or planting materials from other countries, to fulfil the following two mandatory requirements: 1) obtain an import permit before importing any material, and 2) obtain a phytosanitary certificate from the country of origin. These two documents must accompany every consignment of seed or planting materials imported from abroad. The primary objectives of the PQ Order of 2003 are to prevent the introduction and spread of exotic pests that are destructive to crops, by regulating and restricting the import of plants and plant products; and to facilitate the safe movement of germplasm for research and the trade of agricultural commodities, by providing a technically competent and reliable phytosanitary certificate system for producers and exporters to meet the requirements of trading partners. The major activities pursuant to these policies include:

- Quarantine examination and treatment of germplasm and transgenics imported for research purposes, and supply of pest free germplasm to researchers in India
- Inspection of imported agricultural commodities to prevent the introduction of exotic pests and diseases, inimical to Indian fauna and flora
- Inspection of agricultural commodities intended for export, as per the requirements of importing countries under the International Plant Protection Convention (IPPC)
- Survey and surveillance for the detection of exotic pests and diseases already introduced, in order to contain and control them by adopting domestic quarantine regulations
- Conduction of post-entry quarantine inspection of identified planting materials
- Conduction of Pest Risk Analysis (PRA), to finalize phytosanitary requirements for importing plants and plant products

The commercial import of seed of coarse cereals, pulses, oilseeds and fodder crops; and rootstocks and seedlings of fruit plant species for propagation, shall only be permitted based on the recommendation of the Export–Import [EXIM] Committee of the Department of Agriculture and Cooperation (DAC), except the trial material of 19 crops specified in Schedule XII of the PQ Order of 2003[4]. The Plant Protection Advisor (PPA) to the Government of India, or other issuing authorities as listed in Schedule X, shall issue the permits for importing seed and plants intended for sowing or planting, and for importing plants or plant products intended for consumption. The import permits shall be issued subject to such conditions and restrictions prescribed in Schedule V, VI and VII. All consignments of seeds and plants for propagation, and regulated articles such as live insects, microbial cultures, bio-control agents and soil, shall only be imported into India through regional plant quarantine stations in Amritsar, Chennai, Kolkatta, Mumbai, or New Delhi.

Issue of import permits for importing germplasm into India

The Director of the NBPGR has been authorized to issue import permits and receive imported materials from customs authorities, for its quarantine inspection and clearance. In order to obtain a permit to import seed or planting materials, a specific application form – PQ Form 08 – must be filled and submitted to the Director of the NBPGR in New Delhi. The import permit is issued as PQ Form 09, in triplicate. The permit is valid for six months from the date of issue, and is valid for successive shipments provided the

[4] *See: http://plantquarantineindia.nic.in/PQISPub/html/PQO_amendments.htm#.*

exporter and importer, bill of entry, country of origin and phytosanitary certificate are the same for the entire consignment. Validity may be extended for up to one year on request, if adequate justification is provided in written form. Import permits are non-transferable.

After obtaining an import permit, the recipient should send it to the supplier of the germplasm that is intended for use in research, with the request that the import permit be enclosed in duplicate along with the seed or planting materials.

The Director of the NBPGR is authorized to issue permits for importing seed or planting materials intended for research purposes only, as per clause 6 (2) of the PQ Order of 2003. The application form (PQ 08) can be downloaded from the NBPGR website[5].

In addition to the application form PQ 08, it is also necessary to pay a non-refundable fee to the Director of the NBPGR. It must also be ensured that the consignment is addressed to the Director of the NBPGR. Furthermore, the seed or planting materials should not be treated with any chemical until, and unless, asked to do so in the import permit. The port of entry for germplasm is New Delhi Airport only.

Phytosanitary certificates

The second mandatory requirement is that of holding a phytosanitary certificate, which should be issued by the official agency of the donor country. Phytosanitary certificates concern the health status of a consignment. Each consignment must be accompanied by such a certificate, which is issued by authorized officers in the country of origin (or the supplier country), with additional declarations attesting to the fact that the materials are free from specific pests and diseases, or that the pests concerned do not occur in the country or state of origin, as supported by documentary evidence thereof.

Phytosanitary certificates are also issued by the Plant Quarantine Division of the NBPGR for all germplasm intended for export to foreign countries. Every import should be accompanied by a phytosanitary certificate (original copy) issued by the competent government official from the country of origin, in the format prescribed by FAO[6].

Issuing import permits for transgenic crops

The 'Rules for the manufacture, use, import, export and storage of hazardous microorganisms/genetically engineered organisms or cells' were created under the Environment (Protection) Act (EPA) 1986 (No. 29 of 1986)[7]. The EPA plays a major role in minimizing the risk from pollutants and contaminants affecting flora and fauna, human and animal health, and in preserving the environment. In accordance with this Act, all transgenic plants are regulated items. The provisions of the PQ Order of 2003 are also applicable to the import of transgenic seeds.

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5 *See: www.nbpgr.ernet.in.*

6 *See: http://www.ippc.int/file_uploaded/1304451840_ISPM12_En_2011-05-03.pdf. (International standards for phytosanitary measures, guidelines for phytosanitary certificates, page 16-17).*

7 *As defined in the Gazette of India, extraordinary Part II, Section 3, sub-section (1), published by Authority no. 621, New Delhi. See: http://www.envfor.nic.in/legis/env/env1.html.*

The Department of Biotechnology, the Ministry of Science and Technology, and the Ministry of Environment and Forests (MoEF) have separate sets of prescribed procedures for granting permission to import transgenics. An indentor (that is to say, an applicant) who wishes to import transgenic material has to submit the proposal through the Institutional Biosafety Committee (IBSC), to the Review Committee on Genetic Manipulation (RCGM). The RCGM is an authorized agency of the Government of India that functions under the Department of Biotechnology (DBT). It assesses applications for importing transgenic material for research purposes, and issues seed transfer clearance letters (valid for one year); it also examines the desirability of importing transgenic lines, from the biosafety point of view. The RCGM comprises representatives from the DBT, the Indian Council of Medical Research (ICMR), ICAR, the Council of Scientific and Industrial Research (CSIR), and other experts in their individual capacity.

The Genetic Engineering Approval Committee (GEAC), which functions under the MoEF, regulates the commercial introduction (large-scale use or experimentation) of transgenic material (Singh, 2001). The RCGM recommends the GEAC to consider the release of transgenic material that is deemed to be environmentally safe. After obtaining technical clearance to import the material from the RCGM, the indentor must apply to the Director of the NBPGR for an import permit.

Along with the application form, the indentor is also required to furnish information and provide an undertaking, as per paragraphs 4, 5 and 6 of the DBT permit. This undertaking should be typed on letterhead and signed by the applicant.

Release of the consignment to the indentor

After obtaining an import permit, the recipient should send it to the supplier (abroad) that has agreed to provide the required germplasm for use in research. The supplier should be instructed to send two copies of the import permit (one pasted outside the seed parcel and the other included inside the seed packet), and other relevant documents with the consignment. The import permit must be enclosed in duplicate along with the seed or planting materials for customs clearance. The supplier should be clearly instructed to ensure the consignment is addressed to the Director of the NBPGR. The port of entry of germplasm is New Delhi Airport only.

After quarantine clearance, the material is assigned an exotic collection (EC) number, which remains unchanged, and the material is then forwarded to the recipient.

Registration, national accessioning and the quarantine of imported germplasm

All indents (that is to say, requests) for import of germplasm are registered; after being assigned with a case number, they are then forwarded to the Plant Quarantine (PQ) Division, without opening the parcel, along with the completed import quarantine (IQ) form, for detailed quarantine inspection and clearance. Following clearance by the PQ Division, the samples are arranged taxonomically, indicating their genus, species, common name and cultivar name, etc., for national accessioning and inclusion in the national records. Each imported accession is assigned an EC (exotic collection) number, which remains unchanged, and information such as the name and address of donors; characteristics of the germplasm; relevant references; date of arrival; condition; and distribution of the materials, is recorded. All healthy plant materials are regularly transferred to the various researchers to make use of these valuable genetic resources.

Documentation of information in the national database

The accessioning of imported exotic germplasm is carried out online[8]; each imported accession is assigned an EC number, and then documented, with detailed information being recorded, including:

- Import quarantine (IQ) number and date
- Source country/country of origin
- Complete postal address of the source country
- Import permit number and date of issue
- Phytosanitary certificate number and date
- Biological status, variety name, type, and category of the material

Since 1976, India has received samples of germplasm through the CGIAR Consortium of International Agricultural Research Centres that was originally collected from over 105 countries. Between 1976 and 2010, a total of 2,373,159 samples of different agricultural and horticultural crops were imported from 105 countries, which includes 537,425 germplasm accessions and 1,935,411 samples from international trials/nurseries of CGIAR Centres (see Figure 1).

An analysis of the pattern of germplasm flow into India was carried out for the period 2004–2010. A total of 4,658 import permits were issued, and 244,090 accessions of germplasm were imported, including entries for trials/nurseries for multi-location testing. Most of this germplasm was received from CGIAR Centres (64%); while the Agricultural Research Service of the United States Department of Agriculture (USDA-ARS), and private seed companies both provided 15%. Only 6% of these accessions were provided by universities/countries, based on specific requests (Figure 2).

PROCEDURES CONTROLLING GERMPLASM FLOW OUT OF INDIA

Access and benefit-sharing rules

Pursuant to the Convention on Biological Diversity (CBD), the Government of India enacted the Biological Diversity Act (BDA) in 2002, and the Biological Diversity Rules in 2004[9]. The National Biodiversity Authority was established for the enforcement of the Act and its Rules. Chapter 2 of the Act stipulates that the following natural and legal persons are required to obtain approval of the National Biodiversity Authority before accessing biological and genetic resources and associated knowledge for research or for commercial utilization: (a) a person who is not a citizen of India; (b) a citizen of India, who is a non-resident as defined in clause (30) of section 2 of the Income-Tax Act, 1961; (c) a body corporate, association or organization that is either (i) not incorporated or registered in India; or that is (ii) incorporated or registered in India, under any law currently in force, which has any non-Indian participation in its share capital or management.

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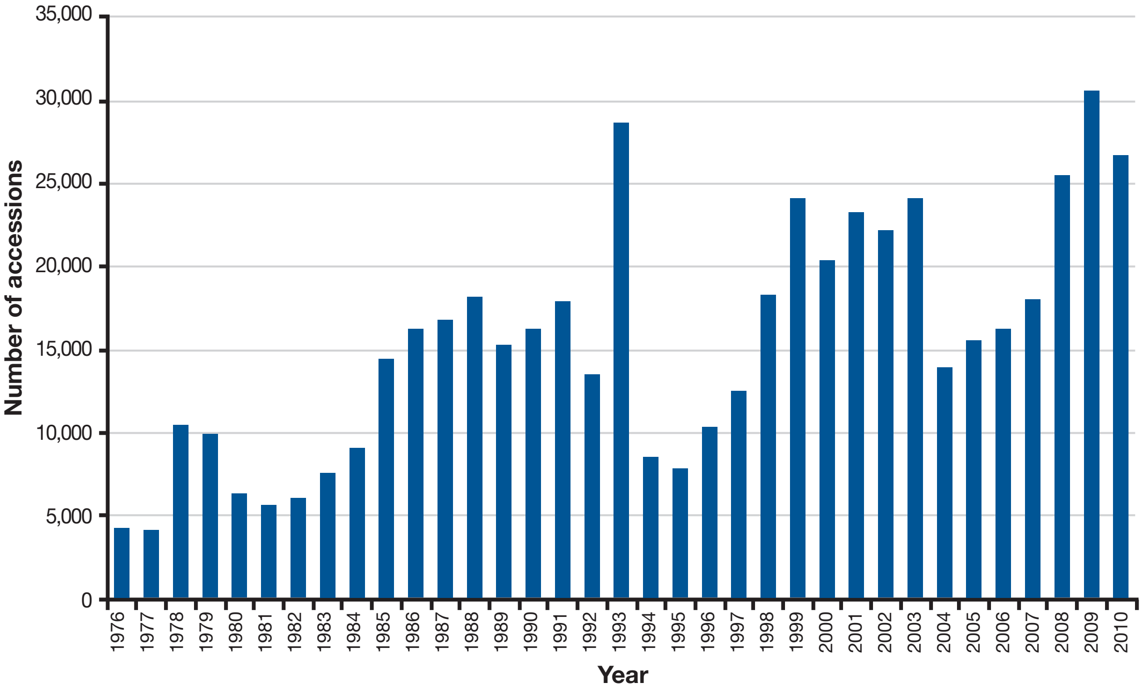
8 *See: http://www.nbpgr.ernet.in/geq.*

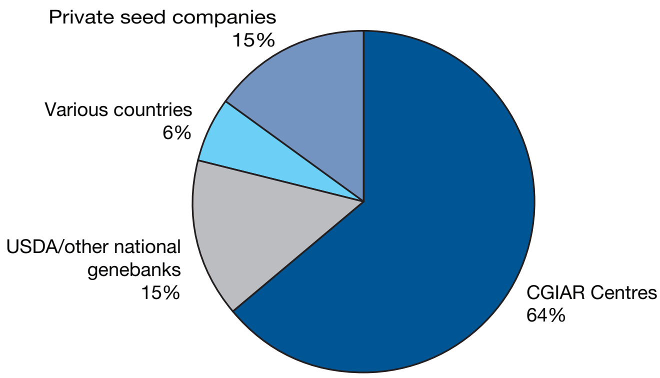
9 *The text of the BDA and Rules can be found at: www.nbaindia.org.*

Figure 1: Germplasm flow into India (1976–2010)



Source: NBPGR

Figure 2: Main sources of germplasm imported into India (2004–2010)



Source: NBPGR

However, under Chapter 2, section 5 of the BDA, germplasm exchanges that are part of collaborative research projects are exempt from the requirements of the Act, when those projects conform to the policy guidelines issued by the Central Government, or are approved by the Central Government. (See Box 1 for more details).

The export of PGRs under the section 5 exemption is scrutinized by the PGR Export Facilitation Committee (PGR-EFC), which submits its recommendations to the Department of Agricultural Research and Education (DARE) for approval. To support this process, applicants should provide the following information to the PGR-EFC:

Box 1: BDA, Chapter 2, section 5 –
'The provisions of sections 3 and 4 shall not apply to collaborative research projects'

5.(1) 'The provisions of sections 3 and 4 shall not apply to collaborative research projects involving transfer or exchange of biological resources or related information between institutions, including Government sponsored institutions of India, and such institutions in other countries, if such collaborative projects satisfy the conditions specified in sub-section 3.'

5.(3) 'For the purposes of sub-section (1), collaborative research projects shall – (a) conform to the policy guidelines issued by the Central Government in this behalf; (b) be approved by the Central Government.'

- Distribution details and a list of germplasm
- Details concerning the indentor of the material
- Information concerning whether the material was introduced under a memorandum of understanding (MoU), and is restored/transgenic
- Additional information/specific traits/remarks if any
- Copy of any collaborative research project documents/MoU/bilateral agreement

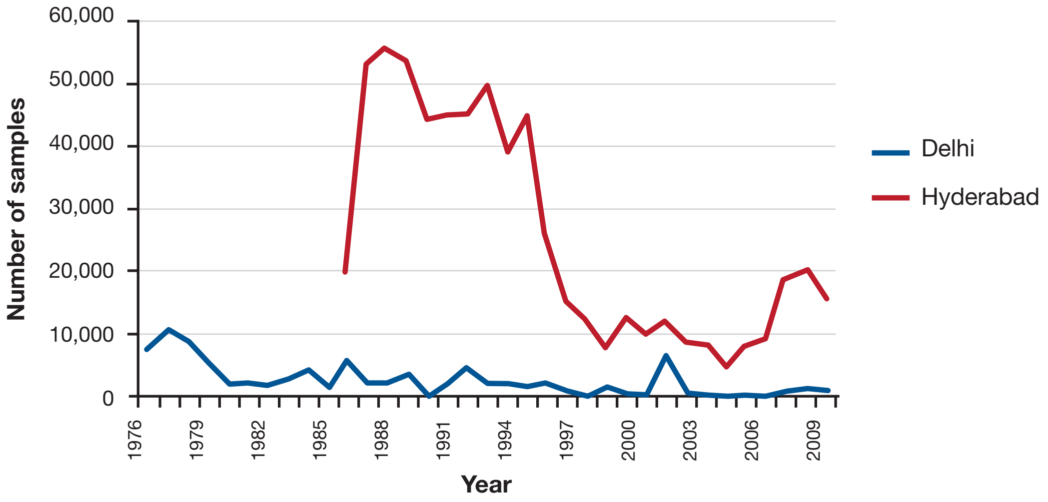
So far, a total of 822 samples of PGRFA have been sent out of India, using the standard material transfer agreement (SMTA), under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), by exercising the discretion created by Chapter 5 of the BDA. In all cases, the materials were sent to CGIAR Centres (Agrawal et al, in this volume).

Since 1976, a total of 723,291 samples have been exported to various countries from NBPGR headquarters in New Delhi, and the quarantine station in Hyderabad. In 1986, the plant quarantine station at Hyderabad was established, and was entrusted with the responsibility of facilitating the export of germplasm of mandate crops of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to other countries. The flow of germplasm to other countries from NBPGR headquarters in New Delhi, and through the plant quarantine station in Hyderabad, is shown in Figure 3. The flow of germplasm to recipients outside India, from 2004–2010, is depicted in Figures 4 and 5 respectively.

PROCEDURES CONTROLLING GERMPLASM FLOW WITHIN INDIA: INLAND SUPPLIES OF PGRFA

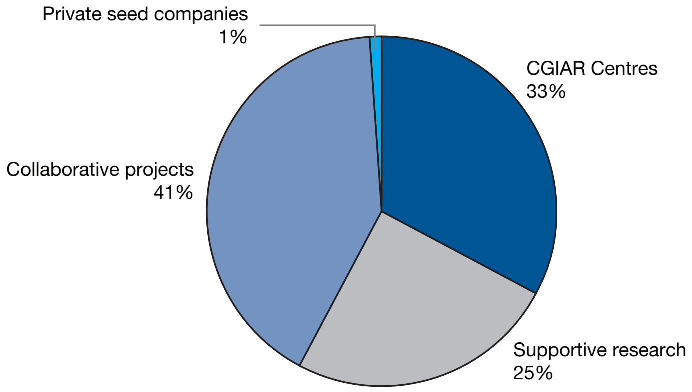
The NBPGR receives a large number of requests from Indian scientists for materials already available in the country. If the desired materials are available in the NBPGR, they are collected and forwarded to the indentor, or else the requests are forwarded to various sources in India, including National Active Germplasm Sites (NAGS), and the material thus procured is forwarded to the indentor under a material transfer agreement. The BDA does not apply to most of these transfers. All requests for germplasm are made by submitting the requisite GEX 01 form. The germplasm is conserved or stored under three categories, and is shared with the researchers, as outlined below:

Figure 3: Export of germplasm from India (1976–2010)



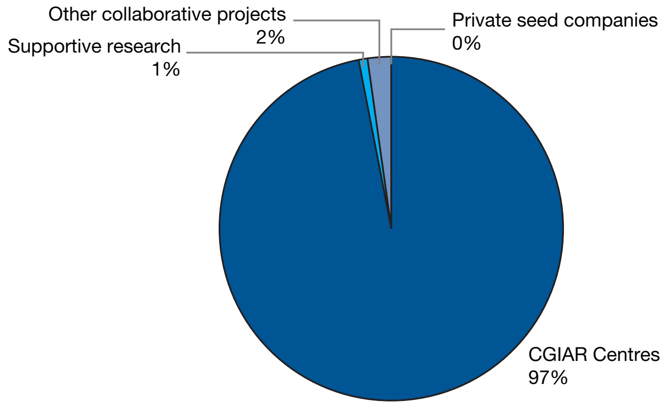
Source: NBPGR

Figure 4: Flow of germplasm out of India, excluding export of ICRISAT mandate crops (2004–2010)



Source: NBPGR

Figure 5: Flow of germplasm out of India, including export of ICRISAT mandate crops (2004–2010)



Source: NBPGR

Base collections

Seed materials are dried to 5–7% moisture content, and are conserved at –18°C for long-term storage or conservation in the National Genebank at the NBPGR, in New Delhi. There are about 380,000 accessions of about 1,500 plant species conserved in the genebank. The seed material from the long-term storage (base collections) is given to the indentors only when the same seed is not available in medium-term storage (MTS), and under the condition that multiplied seed will be deposited in the National Genebank.

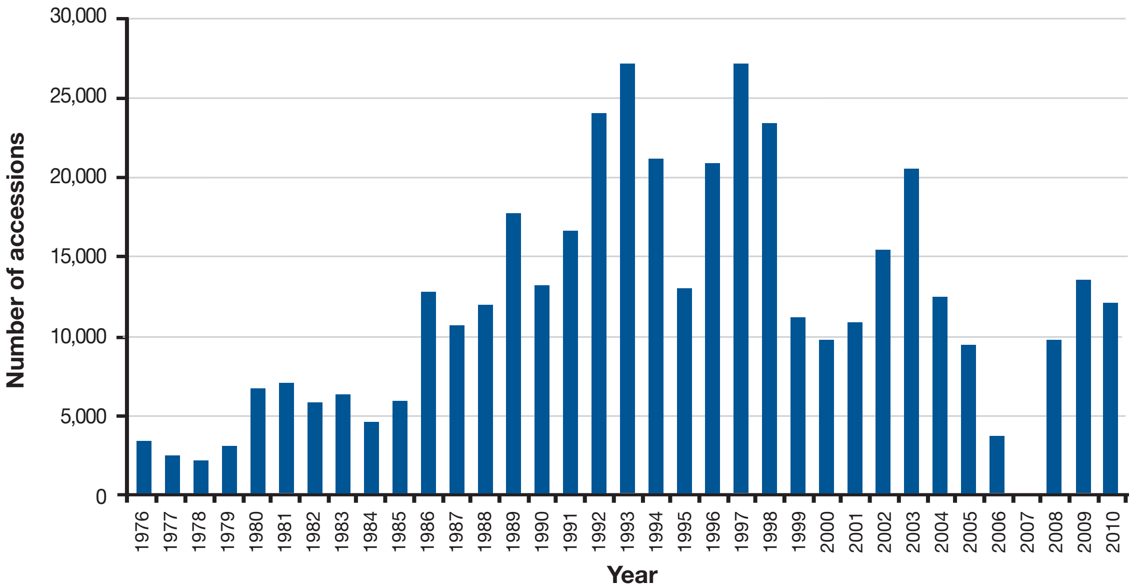
Active collections

Active collections or working collections are stored in medium-term storage at 10°C, and are maintained by breeders and researchers from the various National Active Germplasm Sites (NAGS), comprising NBPGR headquarters and regional stations, ICAR crop-based institutes, and SAUs. Active collections are intended to be used for supplying resources to users on request, under an MTA.

Registered germplasm

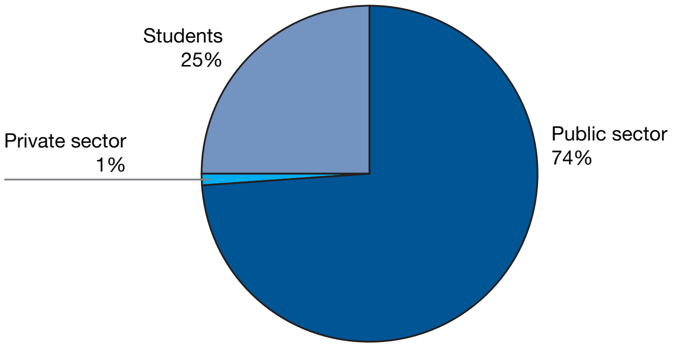
ICAR established the Plant Germplasm Registration Committee (PGRC) in March 1996, with the Deputy Director General (Crop Science) of ICAR as its Chairperson, for the registration of promising and unique germplasm developed or identified by the breeders and researchers in the country. All registered germplasm is conserved at –18°C in long-term storage, and may be shared with researchers under a material transfer agreement. The owner of registered germplasm must be informed when that germplasm is distributed from the collection. More than 400,000 samples have been supplied to researchers and users for utilization in various research programmes, since 1976. Every year, more than 13,000 samples are supplied to researchers and breeders for utilization in various research programmes (Figure 6). During 2004–2010, a total of 84,177 samples were supplied to researchers.

Figure 6: National supply of germplasm (1976–2010)



Source: NBPGR

Figure 7: Flow of germplasm within India (2004–2010)



Source: NBPGR

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9 Village seed banks: the role they play in seed systems and possible benefits they could derive from the multilateral system of access and benefit-sharing

S. Bala Ravi, Advisor (Biodiversity), M.S. Swaminathan Research Foundation (MSSRF), Chennai; and former Assistant Director General (IPR) of the Indian Council of Agricultural Research, New Delhi.

INTRODUCTION

Seed selection and conservation by cultivation are practices that farmers have been following since the dawn of agriculture. It is well recognized that farmers' seed systems (or traditional seed systems) have made phenomenal contributions to the generation of genetic diversity in all crops. Traditional seed systems contribute 60–90% of the seeds planted in many developing countries. As such, the traditional practices of saving seed from harvest, and exchanging, sharing, bartering and selling seed, are of great importance to farmers of these countries. A large part of the traditional seed system is comprised of local varieties. Since the arrival of organized plant breeding in the nineteenth century (or in the case of India, the twentieth century), a new seed system of improved varieties, the so-called formal seed system, came into being. From here on, the traditional seed system is also referred to as the informal seed system. The formal seed system, which is promoted by public and private research organizations, has set new standards concerning the genetic uniformity and physical qualities of seed, since the seed in this system is produced mainly for commercial purposes.

While the informal seed system has the strength of traditional knowledge associated with seed quality and its impact on yield, these quality standards are relaxed to suit the traditional agricultural practices used in different regions. Thus, the informal seed system manifests variable standards in genetic and physical purity. It is also worth mentioning that such variable seed quality standards have contributed to greater genetic diversity. The other advantage the informal seed system has over the formal seed system is its high adaptability to local farming conditions, and its economic and environmental sustainability. The adaptive strength of local varieties largely arises from their better tolerance/resistance to biotic and abiotic stresses, and their ability to offer a modest yield with low inputs. The development and adaptation of crops to different ecological conditions, such as soil, rainfall, temperature and altitude, for meeting the specific nutritional, medicinal, cultural, and spiritual needs of communities, have generated a rich body of traditional knowledge. This knowledge is the product of sophisticated and complex observations, and extensive experience and learning regarding the properties of biota, and their interactions with all the elements of local ecosystems.

On-farm conservation as part of informal seed systems is driven by the utility value of varieties, in terms of their agronomic, adaptive, quality or cultural values in each region. Since this seed system is managed by the community, access to all these varieties is much easier and more cost-effective than to those varieties from the formal or improved seed systems. Local varieties are propagated by the dynamic practices of saving seed from the harvest, and sharing, exchanging or even selling seed at low prices. This process is more easily conducted in the case of self-pollinating or vegetatively propagated crops, than in the case of cross-pollinated crops. On-farm conservation of cross-pollinated crops is usually carried out by those who have extensive knowledge on seed selection and blending. A significant aspect of the informal seed system is the rich traditional knowledge that indigenous peoples, local communities and farmers possess with regards to each accession, in terms of its quality and its agronomic, adaptive and cultural utility. This knowledge formed the basis of the initial identification, maintenance and use of many traditional varieties, landraces and wild relatives, for building the formal seed system. The International Rice Research Institute (IRRI), for example, used a landrace from Orissa, FR13A, to identify the flood resistant gene 'sub1a', and to develop the variety Swarna Submergence 1 (Xu et al, 2006); In addition, IRRI was able to identify a gene for bacterial blight resistance in rice, 'Xa21', from *Oryza longistaminata,* which is maintained by the Bela community in Mali (Gupta, 2006). Although intellectual property rights are accessible in the formal seed system, which is based on the informal seed system and associated traditional knowledge, these rights do not extend to the informal seed system in many contexts. The Indian law on plant variety protection (Protection of Plant Varieties and Farmers' Rights Act, 2001), however, extends these rights to the informal seed system.

SEED BANKS

Seed banks play an important role in the conservation of crop genetic resources. *In situ* conservation on farm, and *ex situ* conservation in genebanks, are two widely used conservation systems. Traditional, short-term storage is carried out by farmers under specific conditions, using their traditional knowledge. Long-term storage takes place in *ex situ* genebanks, at low temperatures and through dehydration. While farmers conserve all kinds of crop genetic diversity, propagated both by seed and vegetative parts, the diversity stored in *ex situ* genebanks comprises mainly orthodox, and to some extent recalcitrant, seeds, and fewer vegetative propagules. Therefore, the crop genetic diversity that is conserved in *ex situ* genebanks represents only a fraction of the total genetic diversity. There is limited coverage of vegetatively propagated diversity under long-term conservation, including tissue culture and cryopreservation. Similarly, the storage of cross-pollinated crops, in small samples of seeds, leaves much of the diversity outside and could lead to genetic drift. As such, *in situ* conservation of several crop species, including perennial or vegetatively propagated crops and their wild relatives, is more effective when conducted in their natural or equivalent (*ex situ,* or on-farm germplasm gardens) habitats. Involvement of farmers in the on-farm conservation of landraces and traditional crop varieties is a valuable and cost-saving approach. The wealth and importance of genetic diversity conserved on farm is well recognized in Agenda 21, which was adopted by the United National Conference on Environment and Development (the Earth Summit) in 1992, as well as in the Global Plan of Action[1] and the International Treaty on Plant Genetic Resources for Food and Agriculture[2]. This underscores the links between *in situ* conservation in farmers' fields and *ex situ* conservation in genebanks. Therefore, an operational linkage between the institutional system available to *ex situ* genebanks, and *in situ* conservation activities, including village seed banks (VSBs), may have synergistic benefits.

1 *See: http://www.globalplanofaction.org/.*

2 *The text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

PRIMACY OF LOCAL SEED SECURITY TO CONSERVATION

Essentially, there are two pathways to achieve seed security in the local seed system. One pathway is that all the farmers within a community produce seeds of all local varieties, through a combination of choices. The second pathway is that just a few farmers specialize in the seed production of different sets of all varieties, and make this seed available to other famers. The functioning of multiple seed producers minimizes the risk of failure in the on-farm conservation of any component of genetic resources. However, this seed system still suffers from two major constraints. The first constraint is the periodic decline or loss in the quantity of seed produced, or the number of plant varieties maintained, due to natural calamities, conflicts, difficulties in safe storage, and poverty. The second constraint, possibly most widely experienced, is the massive shift from the informal to the formal seed system, including seed protected by intellectual property rights (IPRs), to meet seed demands, and keep up with advancements in agriculture. This shift from decentralized to centralized seed production and distribution has been the prime driver of rapid genetic erosion in the recent past.

THE VILLAGE SEED BANK MOVEMENT

An increasing awareness on genetic erosion, and appreciation of its impact on seed security, have motivated the current rural movement to become involved in the practice of community-managed village seed banks (VSBs), or field genebanks that are managed by farmers, and which are often supported by non-governmental organizations (NGOs) or other agencies. A VSB is a collection of seed, largely scouted from the local area, which is conserved and made available among farmers, under variable institutional mechanisms that are managed by the communities concerned. The basic aim of all these banks is to strengthen local seed security, map and monitor local crop genetic diversity, and prevent further loss of any of its components. Seed security is usually achieved as a community action to cope with environmental and economic stress, through the careful choice of farming systems with different crops and varieties that are adapted to a range of environmental conditions. Most VSBs deal only with annual crops, particularly grain crops. There are large variations in the process and management of these seed banks, depending on the custodian community and the NGO involved. These processes, with variations in practices, include: (1) mapping local seed diversity, and conducting seed fairs, exchanges, visits and cross learning; (2) training and capacity-building; (3) promoting the productivity of local cultivars; (4) conducting participatory breeding/selection; (5) linking organic farming with the conservation of traditional varieties; and (6) conducting value chain and market development.

Since women and their traditional knowledge play a leading role in the selection, conservation and storage of seed, they are often placed at the centre of management of many of the VSBs. Some communities also have a management committee for the VSB. The main variations in the structure and functioning of VSBs include the availability or lack of continuous external support; the extent of participation from the community; the capacity of the community to sustainably manage the seed banks, and maintain seed quality during processing and storage; and the methods of seed transaction used. Some of these conservation initiatives oppose the introduction of new varieties and other agricultural technologies, and link conservation with organic farming. Many NGOs and organizations also bring in innovative practices in community seed banking to strengthen seed security (Reddy et al, 2006; Suman Sahai, 2008). One particular NGO established a development fund to support VSBs, and a network of seed-savers (GREEN Foundation, 2005). Most of these NGO-driven initiatives are supported by various donors and also by the national government, although less frequently.

The important role played by traditional farming systems in strengthening the conservation of local varieties has already been mentioned; but one important limitation is that the farming system has to stay largely 'static', as it continues to grow local varieties using traditional practices (Dumanski et al, 2006). The opportunity cost suffered by farmers cultivating local varieties varies, depending on the differential in income generated from traditional varieties, and the alternative opportunities available from improved varieties or cash crops. Policy- and profit-driven changes in the farming system are rapidly pushing out the genetic variability of many locally adapted and neglected crops, along with their wild relatives and associated traditional knowledge. Compensating the practice of on-farm conservation encourages the cultivation of only those varieties that are being 'compensated', which creates new problems. Those supporting compensation for on-farm conservation argue that *ex situ* conservation is also conducted at a high cost, and the farmer has the added advantage of continuous evolution. For example, a study carried out in 2000, on the annual cost of maintaining 666,000 accessions in eleven international genebanks, was estimated at US$ 5.7 million, with variations across the genebanks of between US$ 0.87 and US$ 15.48 on each accession of orthodox and recalcitrant seed; and between US$ 11.98 and US$ 89.35 on each vegetative accession and wild species (Koo et al, 2003). Compensation for *in situ* conservation could be an option, if a monitoring system is in place at local level. A recent study by Bioversity International and the M.S. Swaminathan Research Foundation (MSSRF) investigating models of financial incentives for on-farm conservation of small millet landraces demonstrated the fact that farmers prefer to plant a larger area with favoured local varieties of agronomic superiority, than to plant the least preferred local varieties; consequently, these less popular varieties are threatened by genetic erosion (Raghu et al, 2012). However, farmers were found to be willing to maintain such low yielding landraces with monetary or non-monetary compensation. National and international policies for substantial investment in on-farm conservation are urgently needed to slow down the erosion of genetic diversity. This is also of strategic importance in the context of adaptation to climate change.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) supports the development and maintenance of diverse farming systems, the expanded use of local and locally adapted crops, varieties and underutilized species, and the broader use of a diversity of varieties and species for the sustainable on-farm management of genetic resources (Article 6). One strategy to promote a more dynamic approach to *in situ* conservation on farm is to facilitate better access to and use of crop genetic diversity by farmers. Such access can be promoted not only through the VSBs, but also by linking VSBs to *ex situ* genebanks. The VSBs can also serve as a platform for training farmers, enhancing their awareness on conservation, and promoting markets for local genetic diversity. A seed replacement policy that supports the use of more varieties, rather than focusing on just one or two varieties with a narrow genetic base, is also welcome. There have been suggestions of a shift towards this paradigm, from centralized breeding programmes to participatory plant breeding (Hardon, 1995; Witcombe et al, 1996; Arunachalam et al, 2006). Typically, conventional breeding focuses on yield improvement, with selection carried out under controlled, relatively favourable research farm conditions. While a breeder may not select a particular line or population because it is not the best yielding in all testing sites, farmers may pick up such material on the basis of good performance in their fields and other criteria. Participatory plant breeding (PPB) has the advantage of benefiting from the farmers' knowledge and capacity to select under local conditions with the breeders' expertise and access to broader germplasm. These may contribute towards reducing crop vulnerability and genetic erosion.

TRADITIONAL AND FEMINIZED FARMING AND ON-FARM CONSERVATION

Despite extensive genetic erosion, on-farm conservation in many developing countries is preserving substantial genetic diversity in certain crops. This conservation is largely being carried out by small-scale farmers; farmers in dry-land, or in hilly or mountainous areas; and tribal/indigenous farmers who inhabit remote regions of countries belonging to the Vavilovian centres of crop plant origin. The traditional seed system in these countries still occupies a significant part of the area under cultivation. Decentralized seed production and restricted adaptation, diffusion and exchange under the informal seed system also contribute to genetic diversity. Genetic diversity across regions with different rainfalls and altitudes is common. The communities in these regions are still traditionally, culturally and ethnically bound to the local genetic diversity. The women who hold on tightly to their traditional and cultural values play a central role in conservation. Farming is becoming increasingly 'feminized' in these regions due to male migration to other areas in search of employment. Often, extreme poverty negatively affects the possibility of retaining saved seed until the following sowing season. The VSBs reach out to these poor farmers by providing seed loans.

The development and application of agricultural technologies has had a major impact on the differentiated roles of women within households and communities in relation to the use of plant genetic resources (Borjas, 1998; Song and Manicad, 1999). For instance, the introduction of cash crops and hybrid varieties has, in general, negatively affected the role of women. Again, notwithstanding the crucial contribution women make in the management of plant genetic resources, they benefit far less from extension-support services, training activities or workshops offered by the institutional system. This weakens their expertise, and thus their contribution to conservation. Therefore, in order to strengthen on-farm conservation, there must be greater involvement of women in the design and development of technologies, and equal partnership in the decision-making processes related to the management of PGR, and the sharing of any benefits.

ESTABLISHING BENCHMARKS ON AGROBIODIVERSITY

It is important to set agrobiodiversity benchmarks in every region, in order to facilitate monitoring the extent and pace of genetic erosion, and the degree to which the VSBs contribute to halting the erosion. While methodologies for monitoring *in situ* conservation are still lacking, estimates on genetic diversity and its loss are, in most cases, based on the knowledge of elderly farmers or old reports from genebank collection missions. India's Biological Diversity Act, 2002[3] provides for establishing Peoples' Biodiversity Registers in every *Panchayat* (a political unit comprising a cluster of a few villages), with

[3] *The full text of the Act can be accessed at: http://nbaindia.org/content/25/19/2/act.html.*

the participation of the local community. In the absence of a local database on genetic diversity, these registers serve as a suitable alternative. Frequent awareness-raising activities for communities, on the conservation of agrobiodiversity, carried out by several NGOs, underscores its value for sustainable agricultural production as cultural heritage, and highlights the need to conserve potentially useful genetic resources. Effective community involvement in the building and management of Peoples' Biodiversity Registers is expected to substantially contribute to enhancing the awareness and capacity of local people on conservation and sustainable use. The above-mentioned linkage between VSBs and the *ex situ* genebanks may help in identifying accessions that are common in both banks, and the retrieval of accessions lost during on-farm conservation. This information exchange may also help to identify genetic resources that are overlooked (because they are least-preferred by farmers) in on-farm conservation, and threatened by erosion due to lack of use. In this context, it is important that government agencies responsible for conservation and approval of access (for example, the National Bureau of Plant Genetic Resources, and the National Biodiversity Authority, in India) keep track of other institutions and individuals that maintain and catalogue their own collections of plant genetic resources.

ON-FARM CONSERVATION ACTIVITIES OF MSSRF

Over the last two decades, the M.S. Swaminathan Research Foundation (MSSRF) has contributed significantly to the participatory on-farm conservation of genetic resources through a duel and complementary institutional mechanism, involving the village seed bank (VSB) and the community genebank (CGB). The CGB is a medium-term storage facility, which conserves seed at low temperature and relative humidity. The VSB maintains representative samples of all local varieties, with their periodic regeneration. During each growing season, the VSBs also hold large quantities of seed of all those varieties under cultivation, which are deposited by members. The main crops represented in the seed collections of the different VSBs include rice, small millets, and pulses. Surplus seed is made available through credit and sale. Seed credit is offered to members at a 25% seed interest, returnable after the harvest. The management of the VSBs is conducted by self-help groups (SHGs) comprised of women, who are trained in conservation methods, quality seed production, the legal aspects related to access and benefit-sharing, the management of the seed bank register, and account keeping. The VSBs also study the efficacy of local traditional storage systems for ensuring safe storage. Two of the farming communities guided by MSSRF have gained recognition on both a national and international level, through the Equator Initiative: Innovative Partnerships Award of the United Nations Development Programme (UNDP), in 2002; and the Plant Genome Saviour Community Awards of the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Authority, twice in 2011 and 2012. MSSRF also promotes the culture of conservation by training local young people and forming Agrobiodiversity Conservation Corps (ABCC) and Genome Clubs (GCS) at local schools.

The VSBs are encouraged to deposit a voucher sample of seed collections in the CGB, with MSSRF taking responsibility for its safe custody in trusteeship (Geetharani, 2000). Accessions in the CGB are characterized, along with passport data, ethnobotanical and traditional knowledge, and morphological descriptors; data on the distinctness, uniformity and stability (DUS) may also be available for some of the varieties. The CGB databases are generated with support from the PPV&FR Authority and the Department of

Science and Technology, and are collectively known as the Farmers' Rights Information System (FRIS). FRIS, together with herbarium specimens, provide holistic information on each accession and identity for the purpose of establishing community ownership of the varieties, and ensuring access and benefit-sharing, rewards and recognition for primary conservers in concurrence with both the PPV&FR Act[4] and the Biological Diversity Act. Communities of farmers are assisted for establishing plant breeders' rights on certain varieties. The national database on PGRFA will be better served when all the collections, *in situ* and *ex situ*, are characterized using common descriptors or DUS values, along with traditional knowledge. The development of such databases will require enhancing the capacities of many NGOs and communities in maintaining PGRFA, using the standard practices of characterization. MSSRF deposits a voucher sample of every accession held in its CGB with the National Bureau of Plant Genetic Resources (NBPGR) in New Delhi, as a triple safeguard. In this way, most of the accessions are available in the VSB, the CGB and the National Genebank.

The method MSSRF has been using for the conservation of PGRFA is known as the '4C approach': cultivation, conservation, consumption and commercialization (Swaminathan, 1996). Each component is interlinked with the others. The conservation of a plant genetic resource is driven by the extent to which it is needed by a community, either because of its specific advantages with regards to cultivation and consumption; or because of its cultural or commercial values. The needs of each community are dynamic, as are the conservation needs of different PGRFA. Certain stability in conservation may be possible through value chain interventions, as demonstrated in the case of landraces of small millets (Bala Ravi et al, 2010) or by including landraces of rice in participatory plant breeding (Arunachalam et al, 2006).

MARKETS FOR PROMOTING CONSERVATION

Economic benefits are an important incentive to on-farm conservation, as the majority of conservers are small-scale and often poor farmers. The farming system approach of involving more species and genetic diversity is another way of promoting the on-farm conservation of crop genetic diversity. Market and value-added product development represents a strategy for securing better economic benefits from local crops and their varieties. This may enhance the economic stake in their cultivation. At present, the market space for small-scale producers of such PGRFA and their product diversity is limited. A market that is friendly to these products may play a significant role in their conservation. The capacity to organize production, and secure access to technical expertise for processing, marketing and enterprise building, is generally restricted among rural communities. These activities require long-term commitment and support to achieve significant benefits for the local communities. Private participation in the value chain, with fair deals for these conservers, is another option.

ON-FARM CONSERVATION OF PLANT GENETIC RESOURCES UNDER THE CBD AND THE ITPGRFA

The CBD defines *in situ* conservation as the conservation of domesticated or cultivated species, in the surroundings in which they developed their distinctive properties.

[4] *The full text of the PPV&FR Act is available at: http://agricoop.nic.in/PPV&FR%20Act,%202001.pdf.*

Article 8 of the CBD provides detailed requirements for this type of conservation. Most often, PGRFA are conserved by many actors, including farmers, NGOs, private seed industry, and public institutions. A coordinated linkage among these actors, and their participation in the multilateral system is needed to strengthen access to PGRFA through that system. This linkage, at base level, may be between the national genebank and farmers/individuals, VSBs, and public and private institutions that hold PGRFA within each country; and at second level, between national and international genebanks. This framework, together with the availability of a non-confidential database on PGRFA, may promote facilitated access to PGRFA for farming communities and others within and across countries, subject to the national laws of contracting parties. These linkages and data-sharing across PGRFA under community conservation, collections with private sector, national and international *ex situ* genebanks may help in identifying the overlap of accessions.

Two examples of PGRFA exchanges may be cited as case studies. In 1999, farmers in several coastal villages in the Kedrapara region of Orissa lost all their local varieties, including seed held in the VSB, during a super cyclone. However, they were able to replace the seed of all those varieties lost with seed copies from the *ex situ* collections held in the CGB of MSSRF, which had been deposited there by the Orissa community as backup. Since the *ex situ* collections can only spare a small quantity of seed, local NGOs and other agencies helped to multiply and distribute the repatriated seeds. Another example is that of the repatriation of potato germplasm from the genebank of the International Potato Centre (CIP) to the Potato Park in Peru (Shetty, 2005). CIP holds the world's largest collection of potato genetic resources, the vast proportion of which originates from the Peruvian Andes. The *Parque de la Papa*, or the Potato Park, was set up by the six traditional Peruvian potato farming Quechua communities, under the initiative of the Quechua-Aymara Association for Nature and Sustainable Development. In 2004, the park entered into an agreement with CIP, which was the first of its kind, whereby CIP committed to repatriating about 750 potato varieties from its genebank to the Potato Park. This agreement re-established the rights of indigenous people to control access to these genetic resources, and allowed them to reassert themselves playing a leading role in the management and continued evolution of those materials. This agreement was concluded after the ITPGRFA came into force, and was facilitated, at least in part, by the existence of the ITPGRFA.

In the context of on-farm conservation of PGRFA, Article 9 of the ITPGRFA, which concerns farmers' rights, is important. While the implementation of farmers' rights is delegated to national governments, these rights require the government to (a) accord unrestricted rights to farmers to save, use, exchange and sell farm-saved seed/propagating material; (b) protect traditional knowledge relevant to PGR; (c) ensure that farmers can equitably share in the benefits arising from the utilization of PGR, and can (d) participate in national decision-making related to the conservation and sustainable use of PGR.

Article 11.2 of the ITPGRFA falls short of placing all holders of PGRFA on a common platform for seeking facilitated access. According to this Article, the PGRFA shall include all those listed in Annex I that are under the management and control of the contracting parties (that is, national governments) and in the public domain. PGRFA that are automatically included in the multilateral system may include those conserved in the national government controlled and managed *ex situ* genebanks and germplasm gardens, and those growing wild in forests or protected areas managed and controlled by national governments. The public domain in the context of intellectual property means those products (and materials) that are publicly available, and which are not subject to private ownership under intellectual property laws (Graber and Nenova, 2008). While all the contracting parties have sovereign rights over their own PGRFA and these are held to be under their management and control, the landraces and other farmers' varieties under on-farm conservation, and those PGRFA held by private entities, are kept outside the public domain by the ITPGRFA. All farmers, farmers' groups, NGOs and quasi-public or private institutions are natural and legal persons within a contracting party. Article 11.3 of the ITPGRFA requires contracting parties to take appropriate measures to encourage natural and legal persons within their jurisdiction who hold PGRFA listed in Annex I to include them in the multilateral system of access and benefit-sharing. This is more advisory than mandatory, and hence has so far found a low rate of compliance. According to the ITPGRFA, a review of progress made with regards to compliance was due to be considered within two years of the entry into force of the ITPGRFA, which would have been the first meeting of its governing body, held in 2006 in Madrid. However, the review was postponed to the fifth meeting of the governing body, to be held in 2013 (paragraph 32 of Resolution 4/2011[5]). According to the Secretariat of the ITPGRFA, a few private holders have already notified the Secretariat of their inclusion of material in the multilateral system, while other holders have opted to make the material available though national or international genebanks that are part of the multilateral system (Manzella, D., 2012, personal communication).

Article 12.3. (h) of the ITPGRFA stipulates that access to PGRFA found *in situ* will be provided according to national legislation. It is important to clarify here that while the ITPGRFA distinguishes the PGRFA held under direct control and management of national government from those held by the natural and legal persons (see paragraph above) for the purpose of access, the modalities of the access process are to be defined by the national laws. As stated above, generally speaking, in most countries, including India, material, other than the improved varieties released by the national research system, being managed by farmers in their production systems, would not be considered under the management and control of the national government. Indeed, it is under the management and control of the farmers; so it is not automatically included in the multilateral system. The Indian PPV&FR Act allows farmers and farming communities to establish plant breeders' rights (PBRs) on farmers' varieties. It defines farmers' varieties as those that have been traditionally cultivated and developed by farmers in their fields, or wild relatives or landraces of varieties about which the farmers possess a common knowledge. All those farmers' varieties that are managed by farmers, whether registered or not, shall not automatically be included in the multilateral system of the ITPGRFA. While just a few farmers' varieties may be eligible for PBRs, as of now, all farmers' varieties that are used in the pedigree of a commercial variety registered under this Act will be subject to benefit-sharing, and this benefit-sharing will extend to those farmers or farming communities who are the primary conservers of these varieties. Thus, farmers have private legal rights over all farmers' varieties and most of the wild relatives of crops in India. In addition, access to PGRFA that is under development, including those being developed by farmers, is restricted in the multilateral system by exclusion or discretionary approval of its developer (Article 12.3. (e) of the ITPGRFA). Furthermore, Article 16.2 leaves it up to the contracting parties to ensure the participation (or not) of

[5] *Resolution 4/2011 is available at: http://www.itpgrfa.net/International/sites/default/files/R4_2011_en.pdf.*

private, non-governmental research breeding and other institutions in international PGR networks.

The scope of PGRFA automatically accessible from contracting parties is limited to only those 'under the management and control of contracting parties and in the public domain.' The right to access accessions that are overlapping among international and national genebanks, *in situ* conservation with farmers and holding of private players may require resolutions to extend the right allowed by the ITPGRFA to farmer conservers. Additional materials may be included by the few private holders who voluntarily provide them. The Indian law on access and benefit-sharing, the Biological Diversity Act, does not discriminate with regards to whether the PGRFA is maintained in either *in situ* or *ex situ* conditions, and requires prior approval from the national nodal agency, the National Biodiversity Authority, for access by non-Indian entities.

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10 Empowering farmers to use plant genetic diversity for adapting to climate change

P.N. Mathur, Senior Scientist and South Asia Coordinator, Bioversity International, New Delhi.

INTRODUCTION

Plant genetic resources for food and agriculture (PGRFA) are the biological basis of food security, comprising a diversity of seeds and planting material of traditional varieties and modern cultivars, crop wild relatives and other wild plant species. These essential resources are used as food, feed, fibre, clothing, shelter and energy. The conservation and sustainable use of PGRFA is therefore necessary to ensure crop production and meet growing environmental challenges and climate change. Any erosion of these resources poses a severe threat to the world's food security in the long term. Furthermore, countries are fundamentally interdependent with regards to PGRFA and, in particular, those crop genetic resources that have been systematically developed, improved and exchanged without interruption over the millennia. Food and agricultural production are dependent on genetic resources that are domesticated elsewhere and subsequently developed in other countries and regions. The need to adapt to climate change-related stresses will increase the dependence of countries on PGRFA that have been developed and conserved in other countries and continents.

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) responds to this reality about countries' interdependence on plant genetic resources, and their importance for food security. The ITPGRFA provides a framework for cooperation for the conservation and sustainable use of plant genetic resources. It creates the multilateral system of access and benefit-sharing (multilateral system), which is designed to facilitate streamlined, equitable, low-cost means of exchanging germplasm and information. The chapter will provide examples of how the ITPGRFA, and the multilateral system, provides critical policy support for a wide range of actors – particularly small-scale farmers – to be able to access and use plant genetic diversity as part of their climate change adaptation strategies.

It is well known that crop yields are quite sensitive to change in temperature and precipitation, especially during flowering and fruit development stages. Maximum and minimum temperatures, as well as seasonal shifts, can make a significant impact on crop growth and production. Greater variability of precipitation, including flooding, drought, and extreme rainfall has affected food security in many parts of the world. Therefore, there is an urgent need to develop resilient agricultural production systems that can buffer crops against climate variability and extreme climatic events. Current knowledge suggests that more diversified agricultural systems with a broader range of traits and functions will be better able to perform under changing environmental conditions and are able to mitigate the effects of climate change on overall crop production (Matson et al, 1997; Altieri, 1999). Crop diversification can be achieved through a variety of ways, at both inter- and intra-species level. Increasing farmers' access to broaden the genetic base of farming systems will help them to face variable and changing climates. Having more than one variety can help to mitigate climate change, as different events affect some varieties more than others. The cultivation of different varieties in farmers' fields will help produce varieties better suited to local conditions, and which are dynamically adapted to any on-going changes in the climate. Understanding anticipated shifts in world cropping patterns can be a valuable tool for adaptation planning.

ADVANTAGES OF DIVERSIFIED AGROECOSYSTEMS

Although the idea of building resilience has been studied in a broad range of ecosystems, from coral reefs to forests (Nystrom et al, 2000; Chapin, 2004), this idea has not been well studied in one particular system that is of great importance to human society: the agroecosystem. The development of resilient agricultural systems is an essential topic of study because many communities greatly depend on the provisioning services of such systems (e.g. for food, fodder, fuel) for their livelihood (Altieri, 1999). Many agricultural-based economies have few other livelihood strategies (Tilman et al, 2002), and small-scale family farmers have little capital to invest in expensive adaptation strategies, which increase the vulnerability of rural, agricultural communities in a changing environment. The challenge for the research community is to develop resilient agricultural systems using rational, affordable strategies, so that the ecosystem functions and services can be maintained, and livelihoods can be protected (Lin, 2011). Vandermeer et al (1998) elucidate the main issues linking the role of diversity in agroecosystems to functional capacity and resilience. First, biodiversity enhances the functioning of an ecosystem because different species or genotypes perform slightly different roles, thereby occupying different niches. Second, biodiversity is neutral or negative in that there are many more species than there are functions; thus, redundancy is built into the system. Third, biodiversity enhances the functioning of an ecosystem because those components that appear redundant at one point in time may become important when some environmental change occurs. The key here is that when environmental change occurs, the redundancies of the system facilitate the continued functioning and provisioning of services of the ecosystem. These three hypotheses are not mutually exclusive and change over time and space; therefore, all linkages between diversity and function may be useful for the long-term maintenance of sustainable agricultural systems (Lin, 2011).

Although many recognize that diversity can improve the resilience of agricultural systems to environmental change, the adaptation of increased diversification has been slow for a number of reasons. First, economic policy incentives for the production of monoculture row crops under intensive management have outweighed the perceived incentives to implement diversified systems, although this may change as climate variations increase. Second, many of the efforts to adapt agriculture to climate change have focused on the development of biotech solutions to produce drought-resistant crops, pushing agriculture towards more expensive and intensive forms of management. Lastly, the mistaken belief that biomass production is substantially greater in monocropped systems than in multispecies systems has discouraged the move towards more diversified systems. Such barriers slow the rate of adoption of diversified agricultural systems as adaptation options and must be addressed in order to hasten the implementation of this strategy (Lin, 2011).

SUGGESTED APPROACHES TO ENHANCE THE USE OF PGRFA IN A DIVERSIFIED AGROECOSYSTEM

A major challenge for the implementation of diversified agricultural systems for farmers is finding the appropriate balance of diversification within the farming system to satisfy both production and protection values. Farmers and scientists must consider the variety of ways that diversification can occur within the system and develop methods that best meet their specific needs of crop production and resilience. However, the farmers' decision to move toward diversified agricultural systems will be highly influenced by the ability of the diversification strategy to support the economic resilience of farms. Stakeholder involvement and participatory research are often very useful tools for developing adaptation options that will be adopted by a local community, because these methods recognize that knowledge often lies with the farmers in the field, and that local considerations should be integrated into long-term planning (Rivington et al, 2007). Policy incentives that strongly promote adaptation are also necessary for transitioning agriculture to long-term sustainable production.

A RANGE OF TOOLS TO MODEL CLIMATE CHANGE AND CROP ADAPTATION, AND IDENTIFY POTENTIALLY USEFUL GENETIC RESOURCES

Over the last couple of decades, climatic conditions have been changing rapidly, and are continuing to change at an ever-increasing rate (IPCC, 2007). Some regional production rates may benefit from more favourable climatic conditions, while other regions will face increased climate change-related biotic and abiotic stresses (IPCC, 2007). Where conditions improve, the traditional farming systems will be challenged to exploit the additional production potential. Where conditions deteriorate, rapid adaptation will be vital, as centuries-old coping mechanisms used by farmers may suddenly become insufficient or obsolete for those specific areas (Jarvis et al, 2011). As climate 'migrates' between regions, it will disproportionally affect resource-poor and marginalized farmers who have lower adaptive capacities (Hitz and Smith, 2004; Thornton et al, 2011). It is important to note that 70% of the climatic schemes anticipated in the future are already present on earth. In order to prepare for future changes, farmers must improve their adaptive capacities, which can be accomplished by referencing current climatic situations. Research can help in this effort by improving the understanding of farmers and scientists alike with regards to climatic projections and adaptation pathways. To this end, scientists need to work together with politicians in the development of national plans and policy decisions regarding climate change adaptation.

Several software programmes and tools are already available, both commercially and for free, which can model the effects of climate change using climate databases, presence data, general circulation models (GCMs), etc. Geographic information system (GIS) programmes like DIVA-GIS, a free computer programme, can be used to map geographic data and conduct spatial analysis using biodiversity data[1].

The Maxent tool is based on the maximum-entropy approach for species habitat modelling, and uses the geo-referenced presence points of any species, and environmental layers

[1] *This programme is available, and may be downloaded for free at: http://www.diva-gis.org/. The website also provides free GIS data, current and future climate data, and some processed raster images for scientific use.*

such as temperature, precipitation and bioclimatic factors, to model the range of that species either for current or for future conditions[2]. The floramap software was developed by the International Center for Tropical Agriculture (CIAT). Floramap uses the geo-referenced occurrence data of species to predict the probable distribution of species, based on environmental layers like weather data. It can also create clusters to investigate the possibility of subsections of the calibration set with different climatic adaptation[3].

GENESYS is a global portal for information on plant genetic resources for food and agriculture that is the result of collaboration between Bioversity International, on behalf of the System-wide Genetic Resources Programme (SGRP), the Global Crop Diversity Trust, and the Secretariat of the ITPGRFA[4]. GENESYS includes information on about a third of the world´s genebank accessions that are held in the international collections managed by the CGIAR Consortium of International Agricultural Research Centres, the United States Department of Agriculture´s National Plant Germplasm System, and the European Plant Genetic Resources Search Catalogue (EURISCO). PGRFA in CGIAR collections and EURISCO are available for use under the terms and conditions of the multilateral system of the ITPGRFA. GENESYS stores more than 11 million records on phenotypic characteristics of 2,348,549 accessions in order to help breeders find the genetic variation needed by the world´s farmers. It also includes 19 environmental parameters (temperature, precipitation and bioclimatic factors from the current Worldclim database) for 630,034 accessions from 136,550 sites, which are geo-referenced. As such, this is an important source of information facilitating the effective exchange of plant genetic resources.

Climate Analogues, a web-based tool developed within the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) facilitates the visualization of agro-ecological zones, and the crops suited to these, under a changing climate. It is particularly useful for comparing geographic areas with respect to the cropping systems they can support, and for identifying similarities across these, both based on current and predicted future climate. In addition, the tool addresses a variety of existing challenges to integrating climate forecasting into agricultural investment planning. Researchers are experimenting with a climate analogue matching approach, to identify potentially useful germplasm from within particular countries, and around the globe, to use to adapt to climate changes. The climate analogue tool can use geo-referenced data to predict similar environmental conditions, and was developed jointly by the Walker Institute at the University of Reading (UK), CIAT, and the Climate Impacts Group at the University of Leeds (UK), with the financial support and leadership of the CCAFS[5]. CCAFS describe analogues as ‘sites or years that experience conditions with statistical similarity, primarily in terms of current or future climate, but they can also include additional factors such as soils, crops, and socio-economic characteristics. This helps link top-down global models with targeted field trials or visits. In essence, the climate analogue tool identifies areas where the climate today corresponds to the future projected climate of another location, or vice-versa (i.e. areas where the future projected climate in one site corresponds to the current climate of other site). Spatial analogues identify areas whose climate today appears as a likely analogue to future projected climate for another location, and thus

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2 *The Maxent tool is available and can be downloaded for free at: http://www.cs.princeton.edu/~schapire/maxent/.*

3 *FloraMap is available at: http://isa.ciat.cgiar.org/catalogo/producto.jsp?codigo=P328.*

4 *GENESYS can be accessed at: http://www.genesys-pgr.org/.*

5 *The Climate Analogues tool is available at: http://gismap.ciat.cgiar.org/analogues/.*

represent promising areas for comparative research on adaptation plans. For instance, the tool could be used to arrange farmer exchanges between climatic analogue sites to improve knowledge sharing among communities (at the most basic, local and small-scale) and to provide research opportunities to study whether successful adaptation options in one place are transferrable to a future climatic analogue site (at a larger, more global scale), including the effective exchange of germplasm or crop varieties. In that vein, research may seek to identify possible social, cultural, institutional, or economic obstacles to adaptive change. Meanwhile, temporal analogues make use of past climates as representative time series of future climate, allowing us to identify historic events that might provide insight into the possible future consequences of climate change. In particular, historical data can show us about past behavioural change and how agricultural communities successfully adapt or fail to do so. These case studies can be analysed for lessons learned, thus building understanding on the best ways to improve climate resilience or enable adaptation.'[6]

Thus, Climate Analogues synthesizes vast, complex and disparate data to offer decision-makers a quick, low-cost and user-friendly means of visualizing and analysing those data for planning and decision-making purposes. Although it is particularly robust in its coverage of India, the tool is global in coverage.

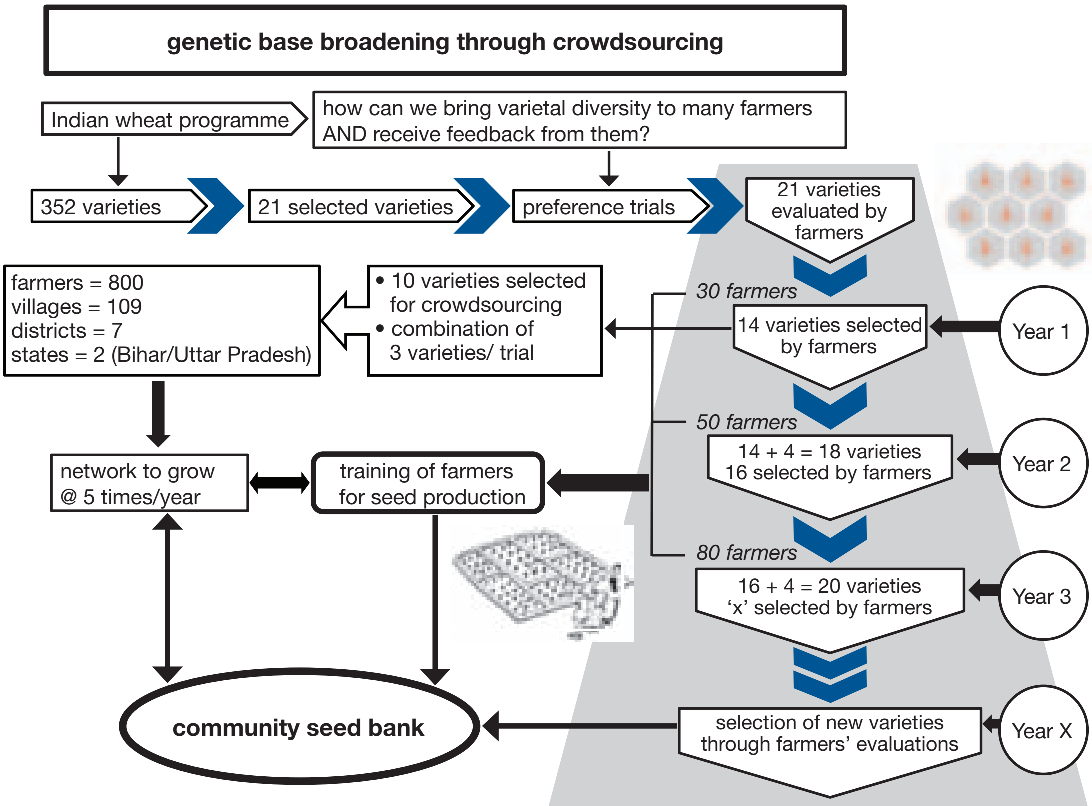
'SEEDS FOR NEEDS': BROADENING THE GENETIC BASE OF CROPS TO EMPOWER FARMERS FOR CLIMATE CHANGE ADAPTATION

Bioversity International (Bioversity) is promoting a crop diversification approach both at inter- and intra-species level for climate change adaptation. Through its 'Seeds for Needs' initiative, Bioversity seeks to increase the access farmers have to crops and their varieties and landraces. As discussed above, crop diversity is essential to respond to climate change challenges. Growing more diversity on farm will contribute to sustainable agricultural production. Experience has shown that farmers are willing to participate in these projects/trials and, as a result of their participation, suitable diversity is being identified and validated by the farmers, and made available to a wide network of farmers. The methodology has been developed through several participatory and crowdsourcing trials in India and is shown in Figure 1. It is expected that the outcome of this approach will include the establishment of a wide farmer-based experimentation network, through which landraces and varieties shall be identified based on the climate analogue approach, and selected by farmers who shall have access to an enhanced seed system through community seed banks.

As part of this initiative, Bioversity is working with several partners in India, including the Indian Agricultural Research Institute (IARI), Humana People to People India (HPPI), and small, local organizations. A series of projects aimed at providing farmers with greater access to crop varieties and landraces, to help them adapt to climate change in Bihar and Uttar Pradesh states of India, are currently being implemented. One such programme, entitled 'Broadening the genetic base of crops to empower farmers for climate change adaptation through crowdsourcing', focuses on the north-eastern plains of the Indo-Gangetic Plain (IGP) region of India. Research and field studies in the past have shown that the Green Revolution introduced Indian farmers to improved varieties

6 *The term 'analogues', as defined by CCAFS at: https://code.google.com/p/ccafs-analogues/wiki/Description?tm=6.*

Figure 1: Broadening the genetic base of crops to empower farmers for climate change adaptation



that were released in specific zones of the country, and seeds of these varieties were made available in those zones in which the variety was released. Over the years, this has resulted in reducing the diversity of varieties that farmers have access to, increasing their vulnerability to changes in the climate. Therefore, in order to reintroduce the availability of the diverse varietal choices to farmers to broaden their genetic base, Bioversity initiated a pilot programme for 21 wheat varieties (DPW 17, PBW 343, PBW 550, HD 2733, HD 2894, WH 711, PBW 502, HD 2932, HD 2967, HD 2985, PBW 373, DPW 621-50, DBW 39, DBW 14, PBW 590, RAJ 3765, WH 1021, HI 1563, HI 1544, K 9107 and CBW 38), which were released over the past over eighteen years for cultivation under different agro-climatic zones (north-west plain zone, north-east plain zone and central zone) of India. These 21 varieties were grown and evaluated by 30 farmers across three villages of Vaishali district in the state of Bihar during *Kharif* (rainy season) in 2011–12. During the crop-growing season, farmers were involved in selecting the best varieties through the participatory varietal selection (PVS) approach. Most of these varieties either performed on a par with, or much better than, the recommended varieties that farmers had been growing in recent years. Normally, farmers in these villages plant only four recommended wheat varieties – PBW 343, PBW 373, UP 262 and DBW 502.

Based on the good performance of these varieties, many farmers showed a keen interest in planting these varieties and requested the seed of many of these varieties. In the *Rabi* season (post-rainy season) of 2012, we began an innovative approach to test the varieties: crowdsourcing (van Etten, 2011). The idea behind this approach is to involve farmers massively in evaluating varieties as citizen scientists. Each farmer grows a combination of three varieties drawn from a broader set of ten. The farmer then ranks them according to different characteristics, such as early vigour, yield, and grain quality. Statistical methods (Fürnkranz and Hüllermeier, 2011) are then applied to combine the rankings and draw inferences from the trials about the varieties. With this information, farmers can then identify the varieties best suited to their conditions and preferences. Farmers participate closely in the trials, actively contributing to science with their time, effort and expertise. Currently, 800 farmers in 109 villages, across seven districts of two states (Bihar and Uttar Pradesh) in India are testing ten wheat varieties, including DPW 621-50, HD 2967, K 9107, K 307, HD 2733, DBW 17, HD 2985, HI 1563, PBW 343 and WH 711, all of which were selected from the previous years' trials by the farmers themselves. Rather than experimentally controlling the trials, the approach relies on the law of large numbers to get good results. The benefit is that the evaluation takes place under farming conditions and that farmers can directly observe how the varieties perform. If they like the varieties, they can reuse the seed, or purchase more. One of the most important uses of the insights obtained from the evaluation is to assist in decision-making on seed distribution in the following year. Promising varieties could be tested more widely, while invariably lowly ranked varieties could be discarded and included in *ex situ* seed collections if their diversity value warrants it. This approach will gradually lead to the identification of a suitable gene pool of crop varieties, selected by farmers in an approach similar to that of PVS, and will lead to the establishment of community seed banks. There are also plans to train farmers in the quality seed production of these selected varieties, for strengthening the local seed system.

'SEEDS FOR NEEDS': APPROACHES TO SOUTH–SOUTH TECHNOLOGY TRANSFER

A similar sort of approach, but on an international scale, can be used to identify potentially useful germplasm and released varieties, and allow farmers and national agricultural research organizations opportunities to experiment with it. Bioversity has been working with partners in a number of countries, and other CGIAR Centres, using the range of tools described above, identifying climate analogues, looking at crop adaptation models, and trying to identify germplasm in collections with potentially useful traits to respond to farmers' needs on the ground.

The climate analogue tool will be utilized in India, as part of a South–South technology transfer and cooperation initiative, to identify adapted PGRFA from India that can be potentially useful in areas in Africa whose climates are becoming more and more similar to the conditions for which the Indian germplasm is adapted. In the initial stage, accession data for the crops of interest will be geo-referenced and the germplasm collecting points mapped. Following this, it will be necessary to identify which accessions out of the entire database match the growing conditions for farmers in different regions in Africa. This can be obtained by clustering the germplasm accessions based on the climate variables (temperature and precipitation) of their collecting sites. The seeds of those varieties that are available from the matching climate sites in India can then be transported to Africa for testing. Similarly, an analysis can be performed for the geo-referenced germplasm accessions in Africa and climate matching can be conducted with regions in India.

POLICY SUPPORT THROUGH THE ITPGRFA AND ITS MULTILATERAL SYSTEM

India became a signatory of the ITPGRFA because it provides a platform for promoting domestic and international cooperation for conservation and sustainable use of PGRFA, promoting farmers' rights, and equitable benefit-sharing (Mishra and Rahate, 2013). Other chapters in this volume describe the ITPGRFA's multilateral system (ITPGRFA Secretariat, in this volume), so it is not necessary to repeat this here. However, it is important to underscore the enormous potential of the multilateral system to facilitate the kind of work described above, ensuring farmers have access to PGR diversity for experimentation to adapt to climate changes. Pursuant to the ITPGRFA, all member states have agreed to virtually pool, conserve, and provide each other with facilitated access to the genetic resources of 64 crops and forages. They agreed to transfer those genetic resources back and forth using the standard material transfer agreement (SMTA), which was adopted by the governing body (which includes India) in 2006. One hundred and twenty-nine countries have joined the ITPGRFA to date. In addition to India, most of the countries of East, Central and West Africa, and an increasing number of countries in South and East Asia have joined the ITPGRFA. Most of the target crops of the projects described above, which India is currently considering as part of technology transfer to Sub-Saharan Africa, are among the 64 crops and forages included in the multilateral system. So too are most of the countries in Africa that are potential recipients of those transferred technologies. The use of the PGRFA in those initiatives falls squarely within the purposes of the ITPGRFA, the multilateral system, and by extension, the SMTA. The multilateral system provides a ready-made, policy framework to support this work, creating legal certainty, an administrative mechanism for tracing and enforcing compliance, and minimizing transaction costs.

CONCLUSION

Broadening the genetic resource base accessible to farmers will enable them to change crops, varieties and farming systems to deal with the effects of changing climatic conditions. The nature of farmers' responses to climate change depends on the socio-economic position of the household – poor farmers are likely to take measures to ensure their survival, while wealthier farmers make decisions to maximize profits. It is therefore imperative to consider targeted policy options, paying special attention to the needs of the poor and small-scale farmers to help them build their capacity to cope with changing climate.

Climate change is projected to change production conditions for agricultural producers globally. In the developing world, most of the projected changes will result in a reduction of agricultural productivity, with concomitant reductions in food security. Therefore, responding to a changing climate will require changes in PGRFA management to address both immediate and slow onset changes. There are a range of adaptation options involving changes in PGRFA management, including changing crops, varieties and farming practices. These options are most often exercised in combination (e.g. changing farming practices also involves changes in crops and varieties). As mentioned above, changes in PGRFA management can be a very effective means of adapting to climate change, and can significantly reduce the projected costs, although effects vary by crop and the level of changes in temperature and rainfall. The literature indicates that both improved and traditional, landrace crop varieties will have an important role to play in adaptation. To date, greater emphasis has been placed on the role of improved varieties and formal sector breeding programmes for adaptation, but greater attention must be paid to identifying the potential role of landraces in contributing to adaptation, and the measures required to realize this potential. The ITPGRFA provides a tailor-made policy and administrative framework to support this work, to ensure that a diversity of adapted germplasm is available for farmers to adapt to climate change-related stresses.

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11 The status of PGRFA conservation and use in India: highlights from India's Second Report on the State of the World's PGRFA

K.C. Bansal, Director, National Bureau of Plant Genetic Resources, New Delhi.
P. Brahmi, Principal Scientist, National Bureau of Plant Genetic Resources, New Delhi.

INTRODUCTION

Sustainable management of natural resources is a primary global concern today. Rapid population growth and technological advances are putting tremendous pressure on these resources. Plant genetic resources for food and agriculture (PGRFA) form the essential building blocks of agriculture, providing food and nutritional security for the world. Over the last four decades of this century, swift progress has been made in the field of agriculture, including the collection, conservation and sustainable utilization of PGRFA. The conservation of PGRFA has now become one of the most widely discussed issues concerning agriculture and the environment. Because of the extent of human intervention in the management of PGRFA, their conservation is linked to their sustainable use. The challenge is to create a new enabling environment that facilitates the sustainable conservation of genetic resources, and accurately reflects their true value in the livelihoods of different stakeholders. In addition, there is a pressing need to incorporate a greater diversity within agricultural production systems. New approaches to agricultural research and development are being tested in various places around the world, and virtually all of them focus on the better use and management of PGRFA.

The rich and varied heritage of biodiversity of India spans a wide spectrum of habitats, from tropical rainforests to alpine vegetation, and from temperate forests to coastal wetlands. It comprises 11.9% of the world's flora, almost a third of which is endemic to the region and is concentrated mainly in the north-east, as well as in the Western Ghats, the north-western Himalayas and in the Andaman and Nicobar islands. Of the 49,219 higher plant species, 5,725 are endemic, and belong to 141 genera distributed among 47 families (Nayar, 1980). Of these, 3,500 can be found in the Himalayas and adjoining regions, and 1,600 in the Western Ghats alone (Arora, 1991). The concept of hotspots was promoted by Russell Mittermeier (Myers, 1988; Myers at al, 2000). These sites support nearly 60 % of the world's plant, bird, mammal, reptile and amphibian species, with a very high proportion of endemic species.

There are 34 such hot spots recognized globally, three of which extend into India – the Himalayas; the Western Ghats and Sri Lanka; and the region around the Indo-Burma barrier, covering the eastern Himalayas. India is blessed with rich agricultural biodiversity, which includes crop plants, wild crops relatives, livestock, aquatic resources, insects and microbes. The Indian gene centre is one of 12 mega-gene centres in the world (Vavilov, 1926). In addition, India is home to nearly one third of all the flowering plants identified and described to date.

The Indian sub-continent is the centre of domestication and diversification for several economically useful wild plant species, comprising about 3,000 edible species; 4,000 species of medicinal value; 700 species of traditional and cultural significance;

500 fibre-yielding species; 400 fodder plant species; 40 insectivorous species; 300 species that produce gums and dyes; and 100 species that produce aromatic and essential oils (Arora, 1991). More than 47,000 plant species can be found in the Indian region, including lower plants (bacteria, algae, fungi, bryophytes, pteridophytes, gymnosperms, etc.). It is a major centre of crop domestication and diversity (Zeven and de Wet, 1982; Arora, 1991). About one third of cultivated plant species have their origins in this region. It is an important centre of origin and diversity of more than 20 major agri-horticultural crops, including rice, beans, cotton, sugarcane, citrus, mango, banana, yams, and several common vegetables and popular species.

About 583 crops are cultivated in India (see Table 1). It is home to 167 cultivated species and 329 wild relatives of crop plants (Arora, 1991), and to 30,000–50,000 landraces of rice, pigeonpea, mango, turmeric, ginger, sugarcane, gooseberries, etc., and ranks seventh in terms of contribution to world agriculture. Furthermore, an estimated 1,000 wild, edible plant species are exploited by native tribes for their various plant parts, including 145 species for their roots and tubers; 521 for leafy vegetable parts; 101 for buds or flowers; 647 for fruits; and 118 for seeds and nuts (Arora and Pandey, 1996). In addition, nearly 9,500 plant species of ethnobotanical use have been recorded in the country, of which around 7,500 are of ethno-medicinal importance and 3,900 are multipurpose, edible species.

Table 1: Crops cultivated in India

Crop group	No. of species
Cereals and pseudo-cereals	12
Millets	16
Legumes	17
Oilseeds	21
Cash crops (sugar and fibre)	16
Vegetable and tuber crops	97
Fruits and plantation crops	139
Forage crops	33
Spices and condiments	27
Medicinal plants	121
Aromatic plants	63
Dyes, pharmaceutical and cottage industry plants	21
Total	**583**

Source: NBPGR

MANAGEMENT OF PLANT GENETIC RESOURCES IN INDIA

Genetic resources of actual or potential value are being lost at an alarming rate owing to habitat destruction, land degradation, over-exploitation of water resources, deforestation, urban expansion, changing social and cultural norms, and the use of improved varieties and technologies of intensive agriculture. This erosion has caused the loss of desirable and potentially useful genes, thereby threatening basic food security. The conflict between modern agriculture and traditional agriculture can be overcome by the use of sustainable farming practices, supported by agricultural policies and institutional mechanisms, and through the scientific management of genetic diversity. A wide genetic diversity provides stability to farming systems and sustains changing environmental conditions that may occur in the future (Gautam, 2004).

The National Bureau of Plant Genetic Resources (NBPGR) is a nodal institution for the management of PGR at national level in India, under the umbrella of the Indian Council of Agricultural Research (ICAR), New Delhi. After its creation in 1976, the NBPGR developed the Indian Plant Genetic Resources Management System, which works in partnership with other organizations. The system has greatly contributed towards safeguarding indigenous crop genetic resources, and has introduced useful PGR into India from other countries, enhancing agricultural production and productivity in the country. As one of the gene-rich countries of the world, India faces the unique challenge of protecting its natural heritage, and developing suitable, mutually beneficial strategies for germplasm exchange with other countries.

EXPLORATION AND COLLECTION

Since its inception, a total of 257,432 accessions, of more than 2,000 species, have been collected by the NBPGR over the course of 2,467 explorations. There has been a significant increase in the number of wild species (12–30%) collected and recorded since 1976. In addition, the NBPGR carried out a number of special exploratory missions to, for example, flood affected areas in Orissa, where samples of flood-tolerant rice landraces, scented rice, tuber crops (*Colocasia* and *Ipomoea batatas)*, as well as amaranth and leafy vegetables were collected. During a visit to tsunami-affected areas (the Andaman and Nicobar islands), important collections of vegetables, pulses and wild relatives were identified *(Vigna marina, Alysicarpus vaginalis, Cucumis saggittatus*, *Corchorus capsularis*, etc). Significant germplasm were collected in the Sunderbans, in West Bengal, including landraces of various saline-tolerant crops, very pungent chilli, and wild turmeric. The driest parts of the cold desert of Lahual-Spiti (Himachal Pradesh) were surveyed with the aim of collecting cold-tolerant germplasm of pulses, vegetables, pseudo-cereals, etc. Of particular interest, was the collection of locally known landraces of radish (Tabung and Makali).

EX-SITU CONSERVATION

Over the years, India has developed sound scientific management regimes for *ex situ* conservation, and access to its genetic resources (Dhillon and Saxena, 2003). Groups of institutions, scientific societies and non-governmental organizations are currently working with the NBPGR, New Delhi on implementing these regimes, through the efficient management of plant genetic resources, and by facilitating access to the various crop improvement programmes. The NBPGR also houses the National Genebank network comprising regional stations and National Active Germplasm Sites.

THE NATIONAL GENEBANK NETWORK

The National Genebank network consists of the National Genebank of the NBPGR in New Delhi, which is primarily responsible for the conservation of germplasm on a long-term basis; as well as ten regional stations, which are located in different agro-climatic zones of the country (Table 2); and 57 National Active Germplasm Sites (NAGSs), which form an integral component of the network.

Table 2: Regional stations/base centres of the NBPGR

Year of establishment	Regional station/ base centre	Mandated crops
1960	Shimla (Himachal Pradesh)	Temperate field and horticultural crops
1965	Jodhpur (Rajasthan)	Agricultural and horticultural crops of arid and semi-arid zones
1977	Akola (Maharashtra)	Pulses and pseudo–cereals
1977	Thrissur (Kerala)	Agricultural and horticultural crops of tropical regions, spices and plantation crops
1978	Shillong (Meghalaya)	Agricultural and horticultural crops of wet subtropical regions
1985	Bhowali (Uttarakhand)	Agricultural and horticultural crops of sub–temperate and subtropical regions
1985	Cuttack (Orissa)	Agricultural and horticultural crops, with emphasis on rice germplasm
1985	Hyderabad (Andhra Pradesh)	Agricultural and horticultural crops, with emphasis on coarse grain, pulses and medicinal plants
1988	Ranchi (Jharkhand)	Tropical fruits and other field crops
1988	Srinagar (Jammu & Kashmir)	Germplasm of temperate crops

Source: NBPGR

The NAGSs are based in the institutions that are primarily responsible for specific crops or crop groups, and they are charged with the task of multiplying, evaluating and conserving active collections, and distributing germplasm to users both at national and international levels. Various national institutes, the All India Coordinated Research Projects, state agricultural universities (SAUs), and other stakeholders, are also linked to the network. International agricultural research centres involved in the conservation and use of PGR are also closely linked to the network, and to the cryo-genebank and *in vitro* genebank maintained by the NBPGR. The *ex situ* seed genebank at the NBPGR comprises 12 long-term conservation units that are kept at –18°C for housing the base collections. The active collections are stored in 22 medium-term units, maintained at 4°C. At present, the genebank holds more than 0.38 million accessions (Table 3). Accessions held in long-term storage for ten or more years are monitored to assess their viability, seed quantity, etc., as per genebank standards; samples/lots that are deemed to be sub-standard are sent to the NAGS for regeneration.

Table 3: Genebank holdings at the NBPGR

Crop groups	No. of accessions
Cereals	150721
Millets and forages	55581
Pseudo-cereals	6682
Grain legumes	57387
Oilseeds	56158
Fibre crops	11543
Vegetables	24478
Fruits	530
Medicinal and aromatic plants	6421
Spices and condiments	2972
Agro-forestry	2442
Duplicate safety samples	10235
Total	**385,150**

Source: NBPGR

Accessions in the *in vitro* repository include tuberous and bulbous crops, tropical fruits species, spices and commercial crops, as well as medicinal and aromatic plant species (Table 4). The cultures are maintained at controlled temperatures and are sub-cultured at intervals of 4–24 months. The *in vitro* genebank conserves various priority crops, which are maintained in storage for short- to medium-term periods. The major components of the National Genebank include the seed and field genebanks, and the cryo-genebank facility, which has accessions of varied germplasm of orthodox, intermediate and recalcitrant seed species, in addition to pollen samples.

Table 4: Holdings in the ***in vitro*** repository at the NBPGR

Crop group	No. of species	No. of accessions
Tropical fruits	14	416
Temperate and minor fruits	41	318
Tuber crops	12	594
Bulbous and other crops	11	171
Medicinal and aromatic plants	28	170
Spices and industrial crops	27	380
Total	**133**	**2049**

Source: NBPGR

The main constraints on sustaining *ex-situ* collections in the form of an *in vitro* repository are the lack of funding and the limited number of trained staff. For better management practices, including the management of genetic integrity, suitable methodologies need to be developed for such collections. As such, more dynamic, sustainable and complementary plant genetic resources management processes are being adopted, in order to ensure the system meets the requirements of the crop improvement programmes. *In situ* and on-farm conservation strategies are being adopted on a limited scale for both vegetatively propagated species such as *Citrus*, and seed propagated crops such as Himalayan barley, buckwheat and traditional landraces of rice. The outcome of these models is expected to provide inputs for the formulation of such *in situ* and on-farm conservation projects on a larger scale in the country.

EXCHANGE AND QUARANTINE

Germplasm introduction has had a tremendous impact on Indian agriculture. Major exotic germplasm have been introduced and utilized either directly, or in the development of improved varieties. Some important varieties include wheat varieties – Ridley, Lerma Rojo and Sonora 64; rice varieties – IR 8, IR 20, IR 36 and IR 50; oat varieties – Kent and Rapida; pea varieties – Bonneville, Early Badger, Arkel and Harbhajan; cowpea varieties – Pusa Barsati and Pusa Phalguni; French bean varieties – Kentucky wonder and Contender; soybean varieties – Bragg and Lee; sunflower variety, Peredovik; tomato varieties – Sioux, La Bonita and Dwarf Money Maker; onion varieties – Pusa Ratnar and Early Grano; and the cabbage variety, Pusa Drumhead.

Every year over 20,000 accessions of germplasm, and 50,000 samples of trial materials, are received for utilization. More than 420,000 accessions have been supplied to different indentors for use in national research programmes.

The NBPGR is responsible for conducting quarantine checks on germplasm, including transgenic plant materials exchanged for research purposes, and over the years it has developed state-of-the-art facilities to undertake this task. So far, 3,139,542 samples of various crops have been processed for quarantine clearance; infestation/infection/contamination was detected in 161,723 samples, of which 161,501 were salvaged. Several new techniques and treatments have been developed and standardized for the detection and eradication of pests, and for salvaging the infested/infected/contaminated PGR.

CHARACTERIZATION AND EVALUATION

Large-scale conservation efforts, as in the case of the NBPGR, require substantial resources, the use of which would not be justifiable if those resources could not be utilized in crop improvement programmes. It is, therefore, essential that the characterization and evaluation data for these accessions are of high quality, to enhance their utilization. The germplasm of agricultural and horticultural crops are characterized and evaluated by the NBPGR, in collaboration with the crop-based institutes of ICAR and SAUs. 181,325 accessions of different crops have been characterized and evaluated so far. Multi-location evaluations are being carried out to assess tolerance to biotic/abiotic stresses, and identify quality traits in rice, wheat, pigeonpea, chickpea, maize, rapeseed-mustard, eggplant, okra, lentil and Giloe. Core germplasm sets have been developed for okra, mung bean, sesame and eggplant. About 80 crop catalogues have been published on the characterization and evaluation of different crops.

A total of 5,657 samples of oilseeds and 4,391 samples of legumes have been analysed to determine oil and protein content, respectively. In addition, 2,090 samples of various medicinal and aromatic plants were analysed for their active compounds, and promising accessions were identified. An estimated 500 samples of aromatic oils of *Ocimum*, Coriander, *Alpinia galangal*, *Alpinia calcarata*, palmarosa, lemon grass, etc. were analysed for aromatic properties and phytochemical content. Rapid and sensitive high-performance thin-layer chromatography (HPTLC) methods were developed for the estimation of active principle in *Andrographis paniculata* and *Podophyllum hexandrum*.

DNA FINGERPRINTING

DNA fingerprinting protocols have been developed for 33 crops, and the following techniques were used to fingerprint 2,215 cultivars: Sequence Tagged Microsatellites (STMS), Amplified Fragment Length Polymorphism (AFLP), Inter Simple Sequence Repeat (ISSR), Random Amplified Polymorphic DNA (RAPD), and Sequence-related Amplified Polymorphism (SRAP). Specific molecular markers have been identified for testing the seed purity of commercial hybrids of cotton, pearl millet and sorghum; and for identifying citrus rootstocks. Analysis of the genetic diversity of important crops using molecular markers has provided insight into the genetic base of the released varieties of these crops. The studies indicated that there is high variability available for deployment in crop improvement programmes. These studies were carried out in crops such as rice, pigeonpea, mung bean, sesame, tomato, cotton, chickpea, cashew, soybean, mango, and the brassica oilseed species.

INFORMATION MANAGEMENT

A Cell was established at the NBPGR in 1997, in order to provide services in information management; database development and maintenance; Local Area Network (LAN) support, computer hardware and software maintenance; the statistical analysis of PGR experimental data; and guidance on experimental design for researchers. In addition, this Cell takes on consultancy work related to database management in the field of plant genetic resources. It also offers computer training in the management of data concerning genetic resources.

Many online databases related to plant genetic resources and plant varieties have been developed and are being used by researchers in India. The Protection of Plant Varieties and Farmers' Rights (PPV&FR) Authority uses the following two such databases for the purpose of registering extant and new varieties: IINDUS (Indian Information System as per the DUS Guidelines) and NORV (Notified and Released Varieties of India).

The NBPGR website is hosted on its own web server[1], and is maintained and regularly updated by the Cell. The website provides information related to important activities carried out by the NBPGR, and facilitates online application for a 'permit to import seed/ planting material/Transgenics/GMOs (for research purpose)'. In addition, the following documents may by accessed and downloaded from the website: 'Material Transfer Agreement (MTA)'; 'Guidelines for Registration of Plant Germplasm'; 'Guidelines for Documentation and Conservation of Folk Varieties'; 'Guidelines for Submission of Seeds/ Propagules with National Genebank'; 'Approved fee structure for import of germplasm material'; 'Guidelines for Filing Applications of Plant Varieties for Registration under

[1] *The NBPGR website can be accessed at: www.nbpgr.ernet.in.*

the PPV&FR Act, 2001'; and 'Format of Passport Data Sheet for Allotment of IC Number'. Announcements for conferences, training programmes and meetings are regularly updated on the website.

The NBPGR in New Delhi uses a system of registering plant germplasm that is completely different from that of the PPV&FR Act[2]. The system of registration used by the NBPGR is not a system of protection *per se* but rather a way of safeguarding material developed by a breeder through publication and documentation in the public domain. This germplasm registration can be used as evidence, in documentary or other forms, to create and establish prior art. Germplasm that can be registered at the NBPGR includes any well-performing materials for specific and/or multiple traits (they do not necessarily have to have superior yield); mutants or materials with a different ploidy level than the normal; materials that are of academic/scientific importance; parental lines of inbreds; promising experimental materials; and landraces and traditional varieties. Registration forms are available at the NBPGR website. Efforts are being made to get more and more germplasm registered, so as to enhance its utilization.

FUTURE INITIATIVES

All countries are interdependent concerning their PGRFA requirements and cannot acquire and conserve all the resources they need to satisfy all their needs. Collaboration at local, regional and international levels is needed for the acquisition and conservation of germplasm. India ratified the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) based on the recognition of these facts[3]. The implementation of the ITPGRFA, including the multilateral system of access and benefit-sharing, which is the primary focus of this larger publication, is therefore critically important.

Priority collection expeditions are required to identify those areas that have not yet been sufficiently covered, and repeat visits should be made to areas that showed diversity in the past. More emphasis needs to be given to crop- and trait-specific explorations in agrobiodiversity hotspots in the country. New tools of geographical information systems and remote sensing need to be deployed to supplement the existing ground data in PGR programmes, in order to exploit agrobiodiversity, particularly in difficult/inaccessible areas. There has been a deficiency in sampling wild germplasm during the earlier missions, when the focus was on collecting landraces and traditional cultivars. Emphasis should now be placed on the collection and conservation of wild and related species of crop plants that possess many useful genes for resistance/tolerance to biotic and abiotic stresses.

Complementary conservation strategies, involving both *in situ* and *ex situ* approaches, must be adopted. With regard to *in situ* conservation, attention should be given to genetically rich hotspots, including tribal belts, and the network of germplasm conservation should be strengthened and expanded to include all the stakeholders, including the communities. A set of available PGR, together with associated database, must be deposited as a base collection in the National Genebank; a second set should be maintained as an active collection that is accessible for use in plant improvement activities. The germplasm

2 *The text of the PPV&FR Act is available at: http://agricoop.nic.in/PPV&FR%20Act,%202001.pdf.*
3 *The text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

collection in the National Genebank urgently needs to be assessed to identify gaps and duplicates.

Characterization and evaluation are essential for promoting the utilization of materials. A large number of germplasm have yet to be properly characterized and evaluated. The NBPGR is well poised to characterize an entire set of germplasm of some prioritized crops, including wheat, rice, chickpea, pigeonpea and others, in the coming years. These tasks require substantial inputs and a decentralized evaluation network. At present, only a few collections have complete and user-friendly documentation. Developments in information technology have produced the necessary tools for collating, and disseminating information following a network approach.

Furthermore, the application of targeted and precise molecular tools is required in the genomics-driven crop improvement programmes of today. Genomics applications call for higher precision in the characterization and evaluation of genetic resources. Such intensive evaluations should only be practiced if the number of accessions to be evaluated is within manageable limits. Hence, there is now greater emphasis on the identification of 'core sets' and 'mini cores'. These core sets can be subjected to rigorous evaluation and used for the identification of useful genes/alleles with the help of various 'allele mining' procedures. The future impetus is on conducting a detailed characterization and evaluation of germplasm using conventional and modern approaches. These strategies are expected to support:

- The formation of well characterized and evaluated germplasm collections/cores sets that can better contribute to the development of new varieties, and thus produce greater benefits from the use of germplasm
- The identification of germplasm with potential for more direct use by farmers, and which are suitable for specific agro-ecologies
- The application of genomic tools for characterization and evaluation of germplasm, and distant hybridization for accelerating crop improvement efforts
- The use of diverse sources of gene donors in plant breeding programmes, for producing higher levels of genetic diversity in cultivated varieties and agricultural systems

Currently, the focus is on collaborative efforts in multi-location testing – a multidisciplinary approach to the evaluation of genetic resources collections, and the use of targeted genomic tools for identifying useful genes in their accessions. The exploitation of quantitative trait loci (QTLs) from the wild relatives of crop plants that would not pass through the domestication bottlenecks is also being looked into, so that the variability existing in wild relatives of crop plants could be utilized in crop improvement programmes.

Today's crop improvement programmes focus on the development of cultivars that possess genes for resistance/tolerance to abiotic stresses (such as drought/cold) and to biotic stresses (such as pests and diseases); as well as on product quality; better input-use efficiency; and stability of performance. There is also a growing realization that a wider choice and variety of horticultural and agricultural products, with diverse characteristics in terms of taste, colour, nutritional values and period of maturity, is highly valued in the marketplace. The descriptors for evaluation should be modified accordingly, and the search for desired characteristics in the database should be as quick and efficient as possible.

The registration of genetic stocks and elite germplasm needs to be encouraged, in order to promote germplasm exchange and effective utilization. Germplasm developed by public sector breeders have long been freely available to private sector breeders as well. In the changing global scenario under the new regimes on intellectual property rights, the modalities for benefit-sharing in both the private and public sectors will also have to be worked out. This is urgently needed to promote the continuity of germplasm exchange and synergy between the two sectors. Furthermore, models will have to be developed for the sharing of benefits with farmers and communities as well.

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12 Development of information systems for the International Treaty on Plant Genetic Resources for Food and Agriculture

F. López, Treaty Support Officer (Multilateral System), ITPGRFA Secretariat, FAO, Rome.

INTRODUCTION

Article 17 of the International Treaty on Plant Genetic Resources for Food and Agriculture ITPGRFA), placed under Part V 'Supporting Components', states that 'Contracting Parties shall cooperate to develop and strengthen 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, with the expectation that such exchange of information will contribute to the sharing of benefits by making information on plant genetic resources for food and agriculture available to all Contracting Parties'[1].

This chapter contains:

- An analysis of Article 17 in the context of other articles of the ITPGRFA and the decisions adopted by the governing body
- Preliminary information on the major existing information systems on plant genetic resources for food and agriculture
- An identification of some of the major gaps at global level in the area of information exchange
- An outline of possible future work in relation to the establishment of the global information system of Article 17 with a view to strengthening international cooperation on this matter[2]

ANALYSIS OF ARTICLE 17

The reference in Article 17.1 to 'existing information systems' suggests that there is a need to carefully assess existing mechanisms, analyse the relevance of their structure and content, and review the interest and technical capacities of the institutions that operate those systems, to contribute to the development and enhancement of a global system before new systems are established.

The reference in Article 17.1 to the sharing of benefits through the exchange of information reflects Article 13.2, which considers the exchange of information as part of the benefit-sharing in the multilateral system: '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

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1 *The text of the ITPGRFA can be downloaded at: http://planttreaty.org/content/texts-treaty-official-versions.*

2 *This paper is based on the document IT/GB-4/11/9, Vision paper on the development of the global information system in the context of Article 17 of the Treaty, available at: http://www.planttreaty.org/sites/default/files/gb4w19e.pdf.*

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.'

The governing body discussed the linkage between the global information system and benefit-sharing at its third session, when, in fact, it welcomed current efforts to coordinate and improve existing information systems that should build the basis of the 'Global Information System, foreseen in Article 17' (ITPGRFA, 2011a).

Article 17.2 of the ITPGRFA refers to 'early warning' concerning hazards that threaten the efficient maintenance of plant genetic resources for food and agriculture (PGRFA) as one of the components of the information system, based on the notifications sent by contracting parties, with the aim of safeguarding the material. In fact, information is of fundamental importance to the conservation and sustainable use of PGRFA. While most genebanks have some form of information system or inventory, it is not always easy to have access to them, as many of those systems and inventories are not online and there are still few linkages among them. Furthermore, information on the status of *in situ* genetic material is more difficult to document, systematize and share.

Article 17.3 of the ITPGRFA states that: 'Contracting Parties shall cooperate with the Commission on Genetic Resources for Food and Agriculture of the FAO in its periodic reassessment of the state of the world's plant genetic resources for food and agriculture in order to facilitate the updating of the rolling Global Plan of Action referred to in Article 14'.

It can be concluded from the above analysis that the main thematic areas for which the global information system will be relevant are:

- Scientific, technical and environmental, and socio-economic matters, including characterization, evaluation and utilization
- Benefit-sharing, in the form of access to genetic resources catalogues and inventories, and information technologies
- Early warning system on plant genetic resources for food and agriculture

In addition, Article 17.1 requires contracting parties, in the development and strengthening of the global information system, to cooperate with the Commission on Genetic Resources for Food and Agriculture in its periodic reassessment of the state of the world's plant genetic resources for food and agriculture in order to facilitate the updating of the rolling Global Plan of Action.

STOCK-TAKING OF EXISTING MAJOR INFORMATION SYSTEMS

Information systems and tools in support of the multilateral system

The multilateral system of access and benefit-sharing (multilateral system) was launched in January 2007. In the inter-sessional period between the first and the second sessions of the governing body, the Secretariat of the governing body organized the 'first technical consultation on information technology in support of the implementation of the multilateral system of access and benefit-sharing', as a forum to discuss the ways in which information technology could support, simplify and, as far as possible, automate and reduce the transaction costs of the processes involved in the multilateral system.

In the following inter-sessional period, the Secretariat organized a second consultation in December 2008, and worked with potential providers and recipients of material from the multilateral system in order to better identify users' needs, as well as simplify and automate the use of the standard material transfer agreement (SMTA), and develop and test responsive prototypes.[3] Both consultations gathered representatives from contracting parties, stakeholders and experts on information systems on PGRFA and other relevant fields. They promoted fruitful discussions among managers of information systems and databases in order to identify potential synergies for the implementation of the multilateral system.

Based on the outcomes of such consultations, the Secretariat designed an information system in support of the multilateral system that facilitates the reporting obligations of signatories of the SMTA and other activities relevant to the smooth operation of the multilateral system.[4] The Secretariat also developed, in collaboration with the French Agricultural Research Centre for International Development, a stand-alone information tool to facilitate the generation of SMTAs for the transfer of material within the multilateral system.[5]

In May 2012, the Secretariat of the ITPGRFA launched the new version of the voluntary information system developed by the Secretariat in support of the operation of the multilateral system, entitled 'Easy-SMTA'. This system, which is available in six languages, combines the generating and reporting functions of the SMTA with two tools. The first is the Online SMTA Generating and Reporting (OSGR) tool, which supports the entire SMTA workflow, with functions for the generation, revision and acceptance of new SMTAs, as well as for reporting to the governing body on the concluded SMTA. The second tool is the Online Reporting Form (ORF), which focuses exclusively on reporting back to the governing body on concluded SMTAs, offering very similar options to the generating tool. The Easy-SMTA mainly addresses the needs of small providers with these tools, which were designed to compile SMTAs and to report on them to the governing body, according to the requirements outlined in the SMTA and those approved later on by the governing body.

This system guides users in a step-by-step process that is intuitive and easy to use, offering several additional functions, such as uploading spread-sheet files that list the Annex I material being transferred, which clearly saves time. In addition to a number of individual users, some CGIAR Centres, as well as public genebanks mainly in Europe and North America, have used the Easy-SMTA. During its first year in operation, more than a million accessions were reported through this information system, which also facilitates the reporting of non-Annex I materials.

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[3] *The report of the consultation is available at: http://www.planttreaty.org/sites/default/files/TCIT2Re.pdf.*

[4] *The online reporting system can be accessed at: http://mls.planttreaty.org/itt/.*

[5] *The tool is available at: http://www.planttreaty.org/content/information-technology-tools-support-mls.*

Early warning systems and monitoring tools

Over the last twenty years, the Food and Agriculture Organization of the United Nations (FAO) has been accumulating relevant experience on information systems for PGRFA, especially since the establishment of the World Information and Early Warning System (WIEWS) in 1993[6].

WIEWS was established as a worldwide dynamic mechanism to foster information exchange among FAO member countries by gathering and disseminating information on PGRFA, in conformity with Articles 7.1 (e) and (f) of the International Undertaking on Plant Genetic Resources. WIEWS has evolved over the years: in 1998, its first web version was released allowing users to retrieve information on about 6 million accessions from 1,400 *ex situ* collections; in 2000, remote updating capabilities were added to the web system to allow for information to be uploaded directly from national programmes. Automatic data gathering procedures for updating the database of *ex situ* collections have also been activated for web published genebank documentation systems, and inventories of plant genetic resources for food and agriculture, such as the Centre for Genetic Resources, the Netherlands (CGN); the United States Department of Agriculture (USDA); Germplasm Resources Information Network (GRIN); web-based catalogue, EURISCO; and the System-wide Information Network for Genetic Resources (SINGER).

WIEWS was a key source of information for the periodic assessments of the state of the world's plant genetic resources for food and agriculture, which were carried out in 1996 and 2009. Of particular relevance to the assessments was the unique meta-database of WIEWS on *ex situ* germplasm holdings, which now cover over 7.4 million accessions conserved in some 1,750 genebanks around the world.

Country correspondents, who are officially nominated by their respective governments, have been serving as focal points for the flow of information on plant genetic resources between countries and WIEWS. Article 5 of the ITPGRFA requires contracting parties to conduct surveys and develop inventories on PGRFA. This will help to minimize or eliminate any possible threats identified during the process. The long-term objective of the early warning system is that of assembling information to facilitate the implementation of remedial or preventive measures. WIEWS works towards this goal through its network of correspondents, who are asked to provide information on threats to PGRFA. This network mechanism offers great potential and should be expanded to further facilitate the exchange of additional information among its members and other interested users. In this regard, three main forms of reporting on cases concerned with the loss of plant genetic resources, including *ex situ* collections, crop wild relatives and local varieties, have been made available through WIEWS. However, further research on genetic erosion should be carried out to define key indicators and methods for assessing such erosion and its drivers.

Information exchange is specifically listed in Article 14 of the ITPGRFA, in the context of promoting the implementation of the Global Plan of Action, as follows: 'Recognizing that the rolling Global Plan of Action [...] Is important to this Treaty, Contracting Parties

6 *WIEWS can be accessed at: http://apps3.fao.org/wiews/wiews.jsp.*

should promote its effective implementation, including through national actions and, as appropriate, international cooperation to provide a coherent framework, *inter alia*, for capacity-building, technology transfer and exchange of information, taking into account the provisions of Article 13.' At present, the network of WIEWS comprises country correspondents that cover more than 110 countries. Participatory and capacity-building activities for monitoring the implementation of the Global Plan of Action have been conducted through the network in more than 65 countries worldwide over the past seven years. As part of this monitoring effort, key national PGRFA stakeholders have established National Information Sharing Mechanisms (NISM), and published detailed information on the state of conservation and sustainable use of PGRFA in their respective countries, through web portals and databases. NISM data, which includes, *inter alia*, information on more than 24,000 publications, 18,000 projects, 61,000 cultivars and 18,000 stakeholders, can also be accessed through the World Information Sharing Mechanism on PGRFA, and automatically feed the WIEWS database on *ex situ* collections.

In order to promote the provision of technical and financial resources to developing countries - least developed countries in particular – and countries with economies in transition, for addressing national priorities, FAO, together with Bioversity International and the Global Forum on Agricultural Research (GFAR), launched the web-based portal of the facilitating mechanism for the implementation of the Global Plan of Action, in 2007. The portal is a user-friendly access point to information on the sources and availability of financial, technical and information resources on subjects related to the priority activity areas of the Global Plan of Action.[7] Under the facilitating mechanism, more than 730 funding programmes can now be searched for funding opportunities.

Information systems and research at the international level

The conservation of crop diversity in genebanks involves a wide range of activities, each of which is necessary for safeguarding the collections and ensuring that diversity is available to other users. Consequently, the CGIAR Consortium of International Agricultural Research Centres has undoubtedly accumulated a wealth of expertise concerning information exchange on PGRFA, individually and in a collaborative way. Almost all CGIAR Centres have developed their own documentation systems and inventories. One of the most well-known initiatives was the System-wide Information Network for Genetic Resources (SINGER),[8] which was until recently the germplasm information exchange network of CGIAR and its partners. Together, the members of SINGER held around 693,752 samples of crop, forage and tree diversity in their germplasm collections (ITPGRFA, 2011b). SINGER, which was an initiative of the System-wide Genetic Resources Programme of CGIAR, provided easy access to information about that diversity.

As mentioned above, the Secretariat of the ITPGRFA, in partnership with Bioversity International and the Global Crop Diversity Trust, has supported the development of GENESYS,[9] which is an online information portal capable of linking all genebanks worldwide. The project has started to connect existing information systems, such as

7 *The portal can be accessed at: http://www.globalplanofaction.org/.*
8 *In November 2012, SINGER was discontinued and most of the data and functions are, at the time of writing, in the process of being added to GENESYS.*
9 *The portal can be accessed at: http://www.genesys-pgr.org/.*

SINGER, and EURISCO, the web-based catalogue of European national inventories for plant genetic resources, hosted at and maintained by Bioversity International, on behalf of the Secretariat of the European Cooperative Programme for Plant Genetic Resources (ECPGR). At present, EURISCO provides passport information for more than one million samples (accessions) of crop diversity, representing 5,383 genera and 34,823 species conserved *ex situ* in 41 European countries.

GENESYS is an accession-level information system with a user-friendly interface that is being developed to improve global information exchange. In practice, it works as a gateway in distributing information on germplasm accessions. It is currently the largest catalogue of information on accessions that is available to breeders, scientists and other interested users. At the end of 2010, it published full data updates from EURISCO, SINGER and GRIN, which led to an increase in the total number of data records up to 2.34 million. This update also included an increase in the number of accessions with geo-references, which doubled from 300,000 to 610,000.

The portal invites users to generate searches, not only by using accession number or name, but also based on certain desired traits, such as plant height, growing periods at given locations, seed colour, response to specific pests or diseases, and response to various climatic conditions. That type of characterization and evaluation data, along with environmental data based on the longitude and latitude at collection sites, is included in the portal complementing the passport data currently available. At present, the portal provides information on accessions for all major food crops with a focus on the following twenty-two crops: banana, barley, beans, breadfruit, cassava, chickpea, coconut, cowpea, faba bean, finger millet, grass pea, lentil, maize, pearl millet, pigeonpea, potato, rice sorghum, sweet potato, taro, wheat and yam. All of them belong to the list in Annex I of the ITPGRFA. It is expected that the portal will expand to encompass a wider number of crops, by including further information from databases.

The work of CGIAR Centres on crop informatics has also intensified rapidly in recent years, in particular with regards to maize and rice. The International Rice Genebank Collection Information System (IRGCIS) of the International Rice Research Institute (IRRI) publishes the passport data, as well as characterization and evaluation data, of more than 112,952 accessions.

The clearing-house mechanism of the CBD

Article 17.1 sets forth that 'In developing the Global Information System, cooperation will be sought with the Clearing-House Mechanism of the Convention on Biological Diversity.'

The clearing-house mechanism of the Convention on Biological Diversity (CBD), which is coordinated by the Executive Secretary, was established based on Article 18.3 of the CBD[10]. Its mission is to contribute significantly to the implementation of the CBD through the promotion and facilitation of technical and scientific cooperation, among parties, other governments and stakeholders. The 'Strategic plan of the clearing-house mechanism' identifies three major goals:

[10] *The clearing-house mechanism can be accessed at: http://www.cbd.int/convention/articles.shtml?a=cbd-18.*

- The promotion and facilitation of technical and scientific cooperation
- The promotion and facilitation of information exchange among parties, other governments and stakeholders
- A fully operational mechanism with the participation of all CBD parties and an expanded network of partners

National and regional initiatives

There are quite a large number of national and regional network initiatives that currently address knowledge and information exchange on plant genetic resources, among other activities such as training and capacity-building. These networks support the sharing of expertise and provide backstopping in cases where certain members of the network lack the capacity to implement certain activities. In the area of characterization and evaluation of PGRFA, a number of national genebanks have published collection data on the web in recent years, or are in the process of doing so; often, there is an option to order material online.

However, according to the Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture, which was released in October 2010, a significant imbalance exists between regions, and countries within regions (FAO, 2010). The large majority of countries still do not maintain integrated national information systems on germplasm holdings and 'important *ex situ* holdings in at least 38 countries are still, at least partly, documented only on paper (16 countries) and/or in spreadsheets (32 countries). 21 Dedicated information management systems are used to manage passport and characterization data on *ex situ* collections in only 60 percent of the countries that provided information on this topic, while generic database software is used in about 34 percent of countries.' (FAO, 2010).

The lack of a freely available, flexible, up-to-date, user-friendly, multi-language system has limited improvements in documentation in many countries, although in some cases regional and/or bilateral collaboration has helped meet information management needs through the sharing of experiences and tools. Furthermore, where characterization and evaluation data exist, there are still frequent problems in standardization and accessibility, even for basic passport information.

PRELIMINARY IDENTIFICATION OF GAPS AND NEEDS AT GLOBAL LEVEL

Based on the above preliminary information and experiences gained, the Secretariat of the ITPGRFA has identified a number of areas where needs and gaps exist, and where further activities could support contracting parties in developing a strategic vision of the global information system under Article 17 of the ITPGRFA. Those areas and activities are the following:

- Facilitating further work on information standards related to PGRFA, including the updating of the multi-crop passport descriptors (MCPD) to reflect the new set of information available under the ITPGRFA, including the legal status of the material and its status with respect to the multilateral system
- Promoting free and flexible multi-language systems and tools for the characterization and evaluation of PGRFA, and the necessary training of staff for their adoption

- Coordinating partnerships for the connection of existing inventories and documentation systems with databases containing molecular information on PGRFA
- Promoting the integration of online data sets related to PGRFA, with information on other seed-related issues, e.g. the Organization for Economic Cooperation and Development (OECD), and the International Union for the Protection of New Varieties of Plants (UPOV), etc.
- Enhancing linkages within existing international, regional and national information repositories on PGRFA (e.g. EURISCO, USDA-GRIN, NISM, etc.)
- Establishing linkages with traditional and indigenous knowledge information systems, with particular emphasis on the documentation of techniques and practices for the conservation and sustainable use of PGRFA
- Conducting regular surveys of users' needs, and creating feedback mechanisms and tools to gather users' preferences
- Harmonizing the international networks of national focal points providing information on PGRFA

These needs and gaps must be further detailed and investigated in collaboration with major organizations and networks. The large number of ongoing initiatives on PGRFA information, their diverse nature and scope, and the variety of stakeholders involved, may necessitate a further intensive and detailed assessment of needs, and the definition of concrete activities and partnerships for those activities at the global level, for the progress of the global information system in the long term. The development of the global system may benefit from the definition of general principles, which not only form the basis of the system but also shape the content of implementing activities, and constitute the core elements of collaborative partnerships. The global information system should be voluntary, coherent, neutral, quality-focused, user-oriented, sustainable, decentralized and supportive of decision-making.

The following are some general strategic activities that the Secretariat of the ITPGRFA planned to undertake during the 2012/2013 biennium, subject to the availability of funding, in response to current gaps and needs for the initial development of the global information system of Article 17:

- Establish a forum for the harmonization and sharing of PGRFA data with experts from contracting parties and relevant stakeholders
- Prepare a detailed elaboration of existing gaps in the development and strengthening of the global information system, based on the results of a world survey on users' needs by target groups
- Develop an up-to-date detailed inventory of existing strategic initiatives with a high potential for integration into the global information system
- Start a pilot global system, based on existing advanced systems and users' needs, and available financial resources
- Consult relevant stakeholders for the development of a comprehensive strategy and a work plan to be presented to the governing body at its next session

A number of technical strategic studies may be envisaged to pave the way for those activities.

The global information system should support the main programmes of the ITPGRFA, in particular the multilateral system; and the role of the Secretariat could be the promotion of international partnerships and cooperation, the exchange of information and the development of a network of partners, building on existing networks and initiatives. The system should ensure universal access to official ITPGRFA records, reports and documents, with similar functions to those of the CBD's clearing-house mechanism.

FURTHER DEVELOPMENT OF THE INFORMATION SYSTEMS

At its fourth session in March 2011, the governing body 'welcome[d] the efforts underway to coordinate and improve information systems documenting plant genetic resources for food and agriculture, based on existing information systems, in order to develop and strengthen the Global Information System, foreseen in Article 17, consistent with Article 12.3b, of the International Treaty, and requested the Secretary to further develop this Vision Paper'. Furthermore, the governing body 'Recognize[d] that improving access to and availability of information in the Multilateral System continues to be an important priority and that there is a need to support the relevant authorities and entities, particularly in developing countries, in improving their capacity to provide, manage or access information in respect of the Multilateral System'.

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13 PGR informatics at the National Bureau of Plant Genetic Resources: status, challenges and future

S. Archak, Senior Scientist, National Bureau of Plant Genetic Resources, New Delhi.

R.C. Agrawal, Registrar-General, Protection of Plant Varieties & Farmers' Rights Authority, New Delhi.

RELEVANCE OF PGR INFORMATICS

An organized digital information system provides fair and equal access to everyone. The Convention on Biological Diversity (CBD; Articles 7d, 17[1]), and the Global Plan of Action (GPA; priority activities 17 and 18[2]), recognize the need for countries to develop, maintain and exchange information 'from all publicly available sources, relevant to conservation and sustainable use of biological diversity', including 'results of technical, scientific and socio-economic research'. Information of this nature is imperative for planning and implementing activities, promoting sustainable use, and sharing the benefits accrued from its use.

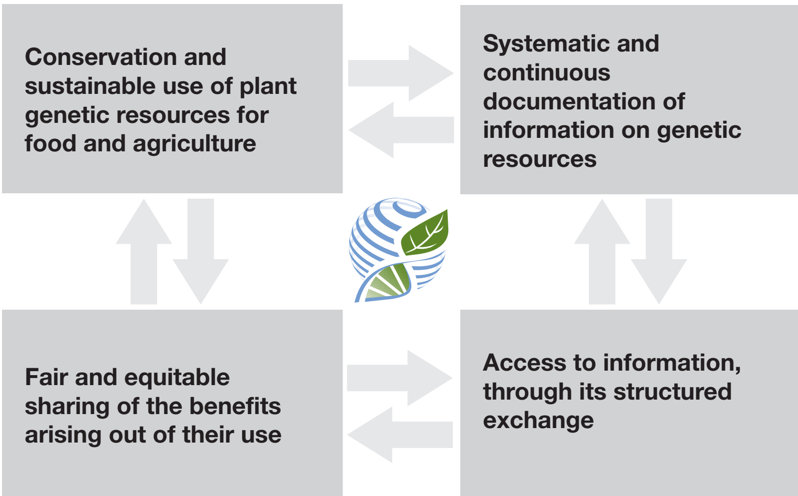


Figure 1: Inter-relationships among the principal tenets of the ITPGRFA

Many of the world's plant genetic resources (PGR) are insufficiently documented. Passport data, as well as characterization and evaluation data, on genebank accessions conserved in genebanks, are either lacking, poorly recorded or scattered across different places, such as passport data sheets; reports of collection and exploration missions; crop catalogues; validated information on local traditional knowledge; published articles; etc. In addition, informal or non-coded knowledge is held by traditional farmers and indigenous people. To use this valuable information efficiently and effectively, it needs to be collected, collated, maintained and exchanged systematically.

1 *The text of the CBD is available at: http://www.cbd.int/convention/text/.*

2 *The text of the GPA can be downloaded at: http://www.globalplanofaction.org/.*

PGR informatics involves the management (i.e. creation, storage, retrieval and presentation), and analysis (i.e. discovery, exploration and extraction) of diverse information (i.e. facts, figures, statistics, knowledge and news). PGR informatics has recently gained significance because of:

- Increased awareness about plant genetic resources for food and agriculture (PGRFA)
- Various international agreements coming into force
- Availability of information in various formats including text, images, maps, and videos
- Availability of technologies to record, link and archive diverse types of information
- Ever-increasing power of computers and the internet to facilitate access and retrieval

THE CALL FOR INFORMATION SYSTEMS IN SEVERAL INTERNATIONAL AGREEMENTS

Article 17 of the CBD requires contracting parties to 'facilitate the exchange of information from all publicly available sources, relevant to conservation and sustainable use of PGRFA'. Priority activity 17 of the GPA promotes the construction of comprehensive information systems for PGRFA, and the exchange of information for enhanced utilization. Article 13.2(a) of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) demands the exchange of information about material included in the multilateral system of access and benefit-sharing (multilateral system)[3].

Furthermore, Article 8(j) of the CBD envisages the preservation of knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of PGRFA; the promotion of their wider use; and the equitable sharing of benefits arising from the utilization of such knowledge, innovations and practices. Additionally, the implementation of the ITPGRFA itself requires greater documentation activities. For example, the standard material transfer agreement (SMTA) requires providers to report each transfer using the SMTA to the governing body (Article 5e); Article 6.9 requires recipients to share publicly available, non-confidential information about uses of materials acquired under the SMTA to a global information system (which will be created pursuant to Article 17); and the third party beneficiary (i.e. the Food and Agriculture Organization of the United Nations - FAO) has the right to request information from recipients of materials under the SMTA (Article 4.4).

ITPGRFA: SPEARHEADING PGR INFORMATICS

The ITPGRFA reflects the aims of both the CBD and the GPA, and proposes the implementation of a Global Information System on PGRFA by ensuring:

- Synergy with the Clearing-House Mechanism (Article 18.3 of the CBD)
- Effective information services that promote and facilitate scientific and technical cooperation, knowledge-sharing and information exchange
- Inclusion of the World Information and Early Warning System (WIEWS) on PGRFA, as a world-wide dynamic mechanism for fostering information exchange to safeguard material

[3] *The text of the ITPGRFA is available at: http://planttreaty.org/content/texts-treaty-official-versions.*

- Periodic assessment of the state of the world's PGRFA as a way of contributing to the implementation of the GPA

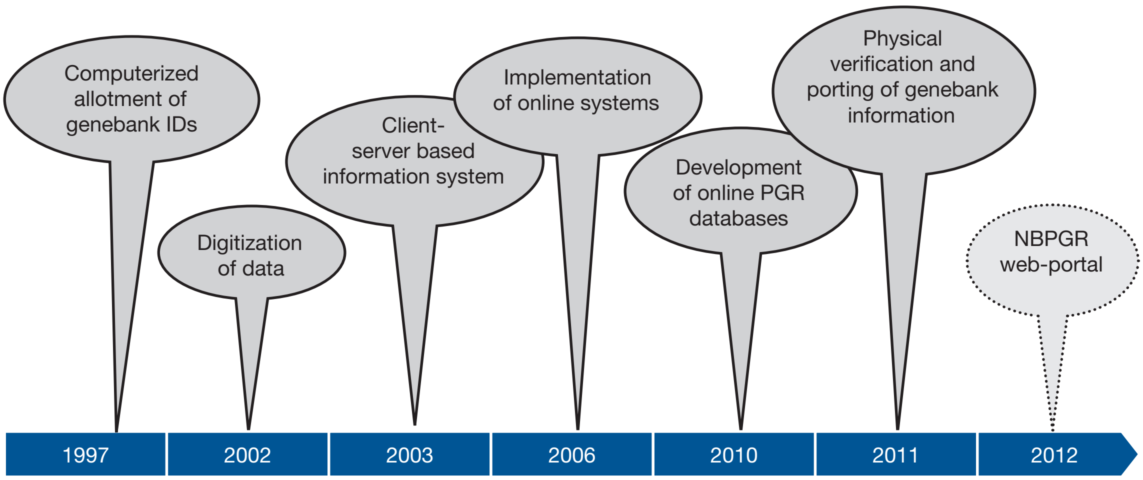
Article 5.1e of the ITPGRFA states that contracting parties commit to 'cooperate to promote the development of an efficient and sustainable system of *ex situ* conservation, giving due attention to the need for adequate documentation, characterization and evaluation, and promote the development and transfer of appropriate technologies for this purpose with a view to improving the sustainable use of plant genetic resources for food and agriculture'. As a result, the following actions must be carried out by contracting parties:

1. Document and share information about PGRFA in the multilateral system
2. Transfer non-confidential research information back into the multilateral system
3. Implement the system of reports required in the SMTA

INDIAN INITIATIVES ON PGR INFORMATICS

The NBPGR is the nodal organization in India responsible for planning, conducting, promoting, coordinating and leading activities related to the collection, conservation, evaluation, introduction, quarantine, exchange, documentation and sustainable management of diverse germplasm of crop plants, crop wild relatives and landraces. The Bureau's network includes ten regional stations, spread out across different phyto-geographical zones, as well as linkages with 59 National Active Germplasm Sites.

Figure 2: PGR informatics at the NBPGR: timeline of evolution



Today, PGR informatics in India has reached the stage where global access is being contemplated. To satisfy practical, domestic requirements, and keep up with the spirit of international instruments in terms of sharing information, the NBPGR has developed its own in-house information systems. Indian Initiatives on PGR informatics include:

- Genebank Information Management System
- Passport Information Management System

- Electronic catalogues of characterization data
- Database of the germplasm exchange inventory
- Germplasm Exchange and Quarantine Information System
- Inventory of Registered Crop Germplasm
- ICAR Plant Variety Information System
- Notified and Released Varieties of India (NORV)
- Indian Information System as per DUS guidelines (IINDUS)
- National Information Sharing Mechanism for PGR (NISM)

CHALLENGES FACED BY INDIAN EFFORTS IN PGR INFORMATICS

In spite of the above-mentioned progress, Indian efforts in PGR informatics have yet to take-off at the scale and intensity expected by the NBPGR; this is attributed to the following challenges:

Operationality

The NBPGR (i) conserves almost all crop species; (ii) carries out all PGR management activities, and hence has to manage multiple types of data (passport, genebank, characterization, exchange, quarantine, DNA fingerprints, etc.); and (iii) manages linkages and coordination among multiple partners. This presumably is not common across genebanks and, therefore, the NBPGR is developing an in-house, multi-module relational information system.

Fragmentation of data

The National Agricultural Research System of India is one of the largest in the world. Different crop-based institutes handle some materials directly, such as seeds; while others are managed through field genebanks, as in the case of some horticultural crops. As a result, data (particularly characterization and evaluation data) are often difficult to collate across years and institutions. Even in the case of collaborative projects, the movement of material and information may not be synchronized. A one-stop programme for collating data and establishing an online system for automatic updates is the most pressing need of the moment.

Data standards

Data standards ensure compatibility among different sources of information, and are thus expected to facilitate information exchange. However, data standards allow multiple data sources and disparate data types to be linked and remote searched in real time, instead of simply maintaining a central repository. This in itself is a mammoth task, but it is further complicated by the need to provide for vernacular Indian languages; and to link past, present and future electronic data.

Germplasm evaluation database

The utilization of PGR directly depends upon the availability of trait-specific germplasm for breeders. Such experiments are not descriptor-based, but are specific trait-based, and are recorded at multiple locations over multiple seasons. Traits primarily include agronomic superiority, tolerance to abiotic and biotic stresses, as well as nitrogen use efficiency (NUE) and nutritional quality. However, global standards in phenotyping and documentation are in the preparatory phase; PGR researchers as well as plant breeders are looking forward to a robust system that is easy to use.

Hi-tech tools

The employment of modern tools and technologies enhances management efficiency, and adds value to the germplasm conserved. Examples of such value addition include the linking of GIS data with passport information, and genomics data with characterization information. Apparently, the benefits are incalculable but implementation is complicated.

Databases and portals

The development of an information system framework that can last for a reasonable period entails making decisions on schema, relations, software, security, the system of access, reliability and queries. The NBPGR has to make well-informed decisions on whether to develop a customized in-house system, adopt existing systems such as ICIS, GRIMS, GRIN-Global, or GENESYS, or develop a novel system of combinations based on the above.

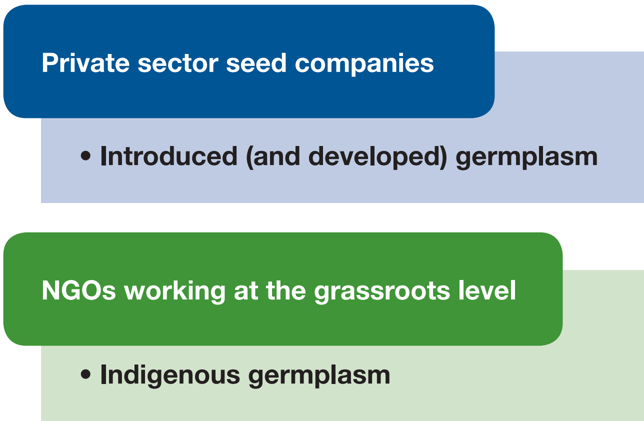
The NBPGR recognizes that working with the international community gives a clear head start on the design, decision-making, and application of standards involved in the establishment of an information system. However, policy-makers would like to ensure that ownership of information will not be compromised beyond the spirit of the ITPGRFA. Among other initiatives, ICAR and Bioversity International are trying to forge a common ground on which the NBPGR can run a pilot project on the global Germplasm Resources Information Network (GRIN-Global), as an in-house genebank information system. Additionally, technical assistance from Bioversity International may be enlisted for working out a limited implementation of GENESYS for use as a national portal.

THE AIM OF THE NBPGR: ACHIEVING GLOBAL STANDARDS IN PGR INFORMATICS

The NBPGR realizes that it is crucial to:

- Develop a national PGR portal, which provides holistic information on all aspects and components of PGRFA, including distribution, taxonomy, availability/access and exchange
- Invite public, private and non-governmental organizations that have data to become partners of a national PGR portal
- Develop an institutional mechanism for maintaining and strengthening the national PGR portal
- Develop accessibility guidelines for various categories of users
- Develop mechanisms for dynamically linking and updating information and inter-operability between participating organizations within India and abroad
- Provide multi-lingual information services in local languages

Figure 3: Engage private sector and NGOs, as active participants and partners



INDIA: A CRUCIBLE FOR THE ITPGRFA?

India is a vast country, in terms of geographical size, and is home to a multitude of languages and dialects, agro-ecological variations, cultivated plants and institutions. The collation and digitization of data on PGRFA in India pertaining to the relevant Articles of the ITPGRFA, the CBD, the SMTA and the GPA, is an enormous task, rivalling regional efforts and involving many countries. The challenges and successes are expected to make the implementation of the ITPGRFA richer, in spirit and in practice.

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14 A road map for implementing the multilateral system of access and benefit-sharing in India

M. Halewood, Head, Policy Research and Support Unit, Bioversity International, Rome.

P.L. Gautam, Former Chairperson, Protection of Plant Varieties & Farmers' Rights Authority, New Delhi; current Vice Chancellor, Career Point University, Hamirpur, India.

K.C. Bansal, Director, National Bureau of Plant Genetic Resources, New Delhi.

P.N. Mathur, Senior Scientist and South Asia Coordinator, Bioversity International, New Delhi.

P. Brahmi, Principal Scientist, National Bureau of Plant Genetic Resources, New Delhi.

INTRODUCTION

This paper provides a synthesis of the most important issues that need to be considered when evaluating options for the implementation of the multilateral system of access and benefit-sharing in India. Building on this synthesis, the paper sets out a road map to be followed as part of India's implementation strategy. The paper draws from, and summarizes, the collective insights and opinions of the participants in the national workshop, 'Strategies for implementing the International Treaty's multilateral system of access and benefit-sharing in India', which was held in New Delhi, 23–25 January 2012.

PART 1: IMPORTANT CONSIDERATIONS

Issues that need to be considered when evaluating options for implementing the multilateral system of access and benefit-sharing (multilateral system) in India can be subdivided into four themes concerning the management of plant genetic resources for food and agriculture (PGRFA); the perspectives of farmers and traditional communities; access and benefit-sharing uncertainties; and bottlenecks affecting the implementation of the multilateral system.

The management of plant genetic resources for food and agriculture

There are already a very large number of PGRFA accessions in genebanks across India. Considerable work is needed to document and centralize information associated with those accessions. In addition to documenting passport and characterization data, it is becoming increasingly important to evaluate those materials on a systematic basis, to identify traits that will be useful to meet current and future challenges; for example, to adapt to climate change-related stresses. Considerable financial and human resources are required to undertake this work, both in India, and for plant genetic resources collections around the world. It is essential to the proper functioning of the multilateral system that information about plant genetic resources collections in the system is both generated and then shared through appropriate online documentation systems.

Those systems need to be capable of receiving and making available non-confidential research information from researchers and breeders regarding PGRFA accessed through the multilateral system, thereby adding value to the resources themselves, and to the multilateral system as a whole. National governments can take the lead in developing and maintaining such information systems concerning materials contributed to the multilateral system. International collaborative mechanisms to support these efforts need to be investigated. Indeed, Article 17 of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) envisages the creation of a global information system where such information can be shared[1]. However, it appears to be a long way from being created. Meanwhile, national governments and other users need to find creative ways to share information about the materials in the multilateral system.

Perspectives and capacities of traditional communities and farmers

A wide range of stakeholders need to be engaged in efforts to conserve and sustainably use PGRFA, including a number of government agencies, civil society organizations, farmers, and traditional communities. Plant genetic resources are the mainstay of farmers' day-to-day livelihoods, and their specialized local knowledge and particular ways of doing things must be taken into consideration in the formulation and implementation of policies. To this end, it is important to include 'farmer security' in discussions for promoting 'food security' under the ITPGRFA. To the extent possible, local institutions and practices related to the conservation and use of agrobiodiversity need to be strengthened in the context of implementing the ITPGRFA, and the multilateral system in particular.

Traditional knowledge can be validated through projects and other forms of interaction with the formal sector and scientific communities. Mechanisms for disseminating traditional knowledge, in its many forms, among communities, are essential. Awareness-raising materials about the multilateral system should be developed in local languages, so that farmers and traditional communities can take advantage of the germplasm and information that are available to them through the multilateral system. In addition, it will be useful for formal sector research organizations and civil society organizations to partner with local communities to assist them to use the multilateral system. Accessing and using the information systems of other countries, in other languages, is often beyond the capacity of traditional communities and farmers. Partnerships with organizations that have such capacity, and can create flexibility for community organizations to learn the requisite skills and set priorities, will be critical to increasing their capacity to take advantage of the multilateral system.

Access and benefit-sharing uncertainties

There are already a multiplicity of international agreements (and related national laws) that address different aspects of access and benefit-sharing and intellectual property rights. These include the Agreement on Trade-related Aspects of Intellectual Property Rights of the World Trade Organization (WTO/TRIPs)[2]; the Convention on Biological Diversity (CBD)[3]; and the International Union for the Protection of New Varieties of Plants (UPOV)[4]. There is already some lack of clarity about how these agreements and laws relate to one another, and how they affect subsets of genetic resources. These

1 *The text of the ITPGRFA is available at: http://planttreaty.org/content/texts-treaty-official-versions.*
2 *See: http://www.wto.org/english/docs_e/legal_e/27-trips_01_e.htm.*
3 *See: http://www.cbd.int/.*
4 *See: http://www.upov.int/portal/index.html.en.*

agreements pre-date the ITPGRFA, and need to be considered when the ITPGRFA is being implemented.

Perspectives on what is the best approach to regulating access and benefit-sharing differ among providers and users, policy-makers and policy implementers across the various sectors (pharmaceutical, industrial, cosmetic, agricultural) that rely on genetic resource use. It has been difficult to reach a consensus on how to regulate private sector involvement, and ensure that it is both fair and equitable. Models of successful access and benefit-sharing regulations and agreements are still relatively few and scattered. It has been hard for negotiators in international policy-making forums to reach agreements on the best ways forward.

One result of this situation is that the exchange of genetic resources between countries is limited. This status quo is not optimal, and some form of simplified procedure, at least for PGRFA, is desirable. The multilateral system is structured to create simplified processes for seeking and obtaining access, and sharing benefits. However, there is still uncertainty about the multilateral system, as different stakeholders have different perceptions. Some of the reasons for this situation are discussed in the following subsection.

Bottlenecks in the implementation of the ITPGRFA

In most countries, beyond a relatively small circle of plant breeders, university researchers, plant genetic resources specialists, farmers and civil society organizations, not many people appreciate the importance of access to genetic diversity for achieving national food security. Indeed, many people are under the mistaken notion that their country is largely self-reliant, in terms of food production, and inputs into their production systems. They would be very surprised to learn that many or most of the foods they eat originated in other parts of the world and even more surprised by statistics related to the number of samples of genetic resources of crops that their countries receive (and send) on an annual basis in support of their agricultural research and development systems. By contrast, stories about genetic resources being unfairly taken out of the country, without permission (sometimes called 'biopiracy') are much more widely appreciated and worried about by the general public. Concerns about controlling such unauthorized access thus overshadow, and to some extent undermine, popular interest in the benefits associated with sharing plant genetic resources through mechanisms like the multilateral system. Clearly, more work needs to be done to raise awareness about the benefits of facilitated access to germplasm through the multilateral system to support national and local research and development objectives.

Depending upon what legal and administrative systems are already in place when a country ratifies the ITPGRFA, it may take coordination and buy-in from a range of agencies to fully implement the multilateral system. For example, if there is already an access and benefit-sharing law in force (as is the case of India), it may need to be amended, or a ministry may need to issue an executive order to create the political and legal space required for the implementation of the multilateral system. Similarly, when it comes to accessing *in situ* materials, most countries already have in place permit systems for accessing and collecting materials from protected areas. Authorities responsible for issuing permits for such areas need to be involved in establishing mechanisms related to the multilateral system for *in situ* materials (e.g. wild relatives in national parks).

Farmers and farmers' organizations, civil society organizations, many companies and other potential participants in the multilateral system likely do not know much about the system, and thus may not have clear ideas about how they can benefit from it. Coordination, awareness-raising and capacity-building for a range of stakeholders will often be necessary as part of efforts by countries to a) encourage 'natural and legal persons' to voluntarily include materials in the multilateral system; and b) learn how to use the system to access germplasm and information for their own use. In the absence of such coordination, facilitation, and outreach, it may be difficult to generate a shared sense of purpose across and among important stakeholder groups concerning the importance of their participating in the multilateral system. Interagency committees, crop and genetic resource networks, farmers' associations, trade associations, agricultural extension services, and civil society networks can play important roles in promoting awareness and use of the multilateral system.

There is concern among some stakeholders that their contributions to the multilateral system will not be adequately recognized, and that once material is in the system, the fact that it came from them will be lost, and their contributions will not be recognized. PGRFA originally collected from a range of countries were brought into the multilateral system through CGIAR Centres, when they signed agreements in 2006, placing materials held in CGIAR genebanks under the framework of the ITPGRFA. The Centres publish records on their own accession-level information systems about where materials were collected, and such records need to be featured on the ITPGRFA website.

The ITPGRFA states that PGRFA that are 'under the management and control' of the national government 'and in the public domain' are automatically included in the multilateral system. In most countries, there are collections that are fairly obviously 'under the management and control' of the national government – e.g. collections in the national genebank that have been created by, and are under the control of, the ministries of agriculture, which are not subject to intellectual property rights (IPRs), and are not held under 'black box' conditions. However, in some cases, it may not be absolutely clear whether a particular collection is actually 'under the management and control' of the national government; for instance, a collection hosted by a public university or autonomous bodies. In such situations, additional consultations will be necessary. Some concerns have been raised about whether backup materials that have been placed in a national genebank as part of a specific project can be automatically considered as being included in the multilateral system. Such cases will require consideration of the conditions under which the collecting occurred, and the agreements that were developed at that time.

Finally, there is uncertainly in some countries about the degree to which existing laws and policies must be amended (or new laws and policies created) in order to begin implementing the multilateral system. A number of countries have decided that they can make significant progress without developing new legislative and policy initiatives, or even amending existing laws. Instead, they have determined that they can rely on exercising existing mandates and decision-making powers to implement the multilateral system, or at least parts of it; for example, making materials available using the standard material transfer agreement (SMTA) from collections that are clearly under the management and control of the national government. In other countries, actors are reluctant to make decisions consistent with the operation of the multilateral system –

for example, distributing Annex I PGRFA from the national genebank using the SMTA – in the absence of high-level, official confirmation (in the form of an executive order, regulation, or law) explicitly empowering them to take such actions.

PART 2: A ROAD MAP FOR IMPLEMENTING THE MULTILATERAL SYSTEM IN INDIA

The following processes or decisions are important for India to implement the multilateral system of access and benefit-sharing.

Confirm what PGRFA are automatically included in the multilateral system

The PGRFA of the 64 crops and forages listed in Annex I of the ITPGRFA that are both 'under the management and control' of the national government and 'in the public domain' are automatically included in the multilateral system, by virtue of a country ratifying or acceding to the ITPGRFA.

In many cases, it is fairly obvious if a collection is under the management and control of the national government and in the public domain. However, it can sometimes occur that the relevant authority (or authorities) may not know about all such collections, or there may be cases where the authority is uncertain as to whether the collection answers this description. To address such situations in India, the following three steps are recommended:

1. Identify the collections of Annex I PGRFA held by national public organizations in India.
2. If there is any reason for doubting that material held by the organization is under the management and control of the national government, evidence, such as the legislation or executive order that led to the establishment of the organization, should be examined in order to ascertain whether or not the organization is independent and can set its own policies regarding the management of the collections concerned, or whether it is subject to the overriding authority of national government. It may also be necessary to examine the conditions under which the organization has agreed to hold the materials. For example, if it has a contractual agreement to hold the material in 'black box' conditions, it may not be considered in control of that material.
3. Once it is confirmed that a collection is under the management and control of the national government, materials in that collection should be assessed in order to ascertain whether they are subject to IPRs (and are therefore not in the public domain).

Consider mechanisms to encourage, and make space for, voluntary inclusion of PGRFA

Under the ITPGRFA, member states agree to encourage natural and legal persons (companies, individuals, groups with legal recognized collective identities) to voluntarily include in the multilateral system, PGRFA of the 64 crops and forages listed in Annex I. In this context, the Indian Government can consider mechanisms to proactively encourage such inclusions, such as requiring recipients of public support for research to make the PGRFA (they are working on) available through the multilateral system.

Equally importantly, it is necessary to consider the means by which materials can be voluntarily included and made available. For example, the national genebank could accept deposits of PGRFA that a company or individual or community wishes to voluntarily include, and subsequently make them available under the SMTA. Alternatively, those same companies, individuals or communities could be allowed to provide the materials directly themselves, using the SMTA.

Confirm or create policy and legal space

Under the ITPGRFA, state parties agree to provide facilitated access to PGRFA in the multilateral system, subject to the access and benefit-sharing conditions included in the SMTA. So, it is necessary to confirm whether or not there are existing laws that would prohibit providers from making material available using the SMTA, such as access and benefit-sharing laws that extend in scope to cover all PGRFA (with no 'carve out' for the multilateral system). Where such laws do exist, it is necessary to analyse how they can be implemented to provide the requisite legal space.

India's national access and benefit-sharing law, the Biological Diversity Act of 2002 (BDA), includes all PGRFA within its scope, but does not include provisions for accessing PGRFA in the multilateral system in ways that are consistent with the ITPGRFA[5]. There is a provision exempting genetic resources that are exchanged as part of projects that have been approved by the national government, and that have been used on a few occasions. But that clause is not broad enough to create the requisite space for the full implementation of the multilateral system. Options for creating the requisite legal space need to be identified and implemented. One possibility discussed at the workshop was that the Government of India could issue a proclamation under Section 40 of the BDA to exempt the multilateral system from the application of the BDA.

Clearly identify who may consider requests and provide access using the SMTA

It must be made very clear who has the authority to consider and approve requests for PGRFA in the multilateral system. Will such authority reside in a single, centralized authority, or will it be dispersed across those organizations that hold PGRFA in the multilateral system? It is possible that a number of organizations will hold PGRFA in the multilateral system, including those materials that are automatically or voluntarily included. In the absence of clarity on this issue, would-be providers will likely be reluctant to respond favourably to requests for materials, even if it is clear that the PGRFA in question are in the multilateral system.

Share non-confidential information about PGRFA in the multilateral system

PGRFA that are automatically or voluntarily included in the multilateral system are not useful if no one knows they are there. The Secretary of the ITPGRFA circulated a request to national ITPGRFA focal points requesting them to share information about the collections that are included in the multilateral system. To date, 23 countries have done so. That information is posted on the website of the ITPGRFA, including, in many cases, links to databases containing accession-level passport, characterization and evaluation

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5 *The text of the Biological Diversity Act is available at: http://nbaindia.org/content/25/19/1/act.html.*

data (that is non-confidential). India may consider providing such information to the Secretary, to be published on the website. Where information about materials in the multilateral system has not yet been included in digitalized information systems, efforts may be made to identify and use an appropriate information system.

India, like other providers, would like to have their contributions to the multilateral system more publicly recognized. Mechanisms for including such recognition should be explored with the Secretariat of the ITPGRFA, and possibly its governing body.

Develop approaches for *in situ* PGRFA in the multilateral system

In situ PGRFA of Annex I crops and forages under the management and control of the national government and in the public domain are also automatically included in the multilateral system. The ITPGRFA anticipates that natural and legal persons will also voluntarily include *in situ* PGRFA in the multilateral system. The organization of collecting missions within countries to gain/provide access to *in situ* materials adds another layer of regulatory complexity. For this reason, the ITPGRFA anticipates (in Article 12(3)(h)) that national laws may need to be developed to establish the appropriate mechanisms for processing such requests.

Use the SMTA for transfers within India

The multilateral system works by passing on benefit-sharing obligations through a chain of transfers until a final new PGRFA product is developed. The system will not work if some of the initial transfers in such a chain are not subject to the SMTA, including when they are sent to India-based users. If such users do not receive the material under the SMTA, they may commercialize it themselves, or pass it on to other companies or branches of their own companies in other countries without the benefit-sharing conditions of the SMTA. This would create an enormous loophole in the multilateral system, allowing a wide range of commercial users both inside and outside India to access materials from the multilateral system without the benefit-sharing obligations. It is important therefore for organizations providing PGRFA in the multilateral system *within India* to use the SMTA.

Consider mechanisms for pooling information about transfers

The SMTA states that all providers must report information about their transfers directly to the governing body. That information is kept in an encrypted data store in Geneva. In addition to providers sending such information directly to the governing body, India may also wish to require providers to send information about transfers to a centralized authority within the country who can maintain a record of all transfers.

Consider mechanisms to facilitate Indian users of the multilateral system

A wide range of stakeholders could benefit from access to the diversity that is available through the multilateral system. However, some users, such as farmers, may not know about the multilateral system, and may lack the capacity to use online databases to identify potentially useful germplasm, and request the provider to send a sample of it. While working through options for implementing the multilateral system in India, policy-makers should consider mechanisms by which they can strengthen the capacity of farmers and possibly other groups to take advantage of the multilateral system.

Recognize practicality as a guiding principle

It may not be possible to simultaneously address all of the issues above, and follow the steps described. For example, while many countries have confirmed which *ex situ* PGRFA collections are automatically included in the multilateral system, none appear to have developed national laws or policies related to providing access to *in situ* PGRFA in the multilateral system (as is anticipated in Article 12(3)h). Similarly, some countries have been able to confirm that some collections in their country are in the multilateral system, and are using the SMTA to distribute samples from those collections; however, they are experiencing delays in confirming the same thing about other collections. If a country such as India is not ready to deal definitively with one particular aspect of implementation, this should not stop the country from making progress with respect to other aspects of implementing the multilateral system. It is possible to take an incremental approach, thereby making progress in a step-wise, but steady, fashion.

Appendix 1

Agenda for the national workshop, 'Strategies for implementing the International Treaty's multilateral system of access and benefit-sharing in India', New Delhi, 23–25 January 2012

Time	Programme		
DAY 1	**Monday, 23 January 2012**		
10.00 – 11.25		Welcome Address	
	10:00 AM	Dr K.C. Bansal, Director, NBPGR	
		Introductory Remarks	
	10:05 AM	Dr Michael Halewood, Bioversity International	
	10:15 AM	Mr Kent Nnadozie, ITPGRFA	
		Address by the Guest of Honour	
	10:25 AM	Dr S.K. Datta, DDG (Crop Science), ICAR	
		Address by the Chair	
	10:35 AM	Dr P.L. Gautam, Chairperson, PPV&FR Authority	
		Inaugural Speech	
	10:50 AM	Dr R.S. Paroda, Chairman (TAAS) & Executive Secretary (APAARI)	
		Vote of Thanks	
	11:20 AM	Dr Pratibha Brahmi, Senior Scientist, NBPGR	
11.25 – 11.45	*Group Photograph and Tea/Coffee break*		
Session I: **Introduction to the International Treaty and the Multilateral System of Access and Benefit-sharing (MLS)** *Chair:* Prof S.K. Datta, DDG (Crop Science), ICAR *Co-Chair:* Mr Gurdial Singh Nijar, Law Faculty, University of Malaya *Co-Chair:* Dr S. Mauria, ADG (IP&TM), ICAR			
11.45 – 12.00	Introduction, meeting objectives, expected outputs	Dr Michael Halewood, Bioversity International	
12.00 – 13.00	Overview of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)	Mr Kent Nnadozie, ITPGRFA	
13.00 – 14.00	*Working Lunch* – Hosted by PPV&FRA		
Session II: **Implementation of multilateral system at national and international level – Issues and current status** *Chair:* Dr P.L. Gautam, Chairperson, PPV&FRA *Co-Chair:* Dr J.S. Sandhu, ADG (Seed), ICAR *Co-Chair:* Dr Hari Upadhyaya, ICRISAT			
14.00 – 14.45	The CGIAR Centers and the International Treaty	Dr Hari Upadhyaya, ICRISAT	
14.45 – 15.15	Efforts to develop information systems to support the Treaty	Mr Kent Nnadozie, ITPGRFA	
15.15 – 15.45	Highlights of national level MLS implementation efforts from the Joint Programme	Dr Michael Halewood, Bioversity International	
15.45 – 16.00	*Tea/Coffee break*		
16.00 – 16.45	The state of implementation of the MLS in India	Dr R.C. Agrawal, Registrar General, PPV&FRA	
16.45 – 17.30	Issues that need to be considered in the course of developing a plan to implement the MLS at national level	Mr Gurdial Singh Nijar, Law Faculty, University of Malaya	

17.30 – 18.30	Small group discussion on issues related to the MLS and SMTA	*Facilitator:* Dr Michael Halewood and Dr Prem Mathur
19.30 – 21.00	*Dinner* – Hosted by Bioversity International	

DAY 2	**Tuesday, 24 January 2012**	
Session III: **Issues of relevance to India's implementation of the MLS** *Chair:* Dr Balakrishna Pisupati, Chairman, NBA *Co-Chair:* Dr P.N. Mathur, Bioversity International *Co-Chair:* Dr R.C. Agrawal, Registrar General, PPV&FRA		
09.00 – 09.30	Status of India's national PGRFA conservation and use	Dr K.C. Bansal, Director, NBPGR
09.30 – 10.00	India's ratification of the Treaty – when, why, how	Dr D.S. Mishra, Registrar, PPV&FRA
10.00 – 10.40	• Community led conservation and farmers' rights • Using rice genetic diversity to support farmers' adaptation to climate change for sustainable production and improved livelihoods in India	Dr Suman Sahai, Gene Campaign
10.40 – 11.00	*Tea/coffee break*	
11.00 – 12.00	The regulation of access and benefit-sharing in India.	Dr Balakrishna Pisupati, Chairman, NBA
12.00 – 12.30	Overview of the application of intellectual property rights to PGRFA in India	Dr S. Mauria, ADG (IP &TM)
12.30 – 13.00	Fostering collaboration between national implementation of CBD and ITPGRFA: Challenges and Opportunities	Dr Sujata Arora, Director, MoEF
13.00 – 14.00	*Working Lunch* – Hosted by PPV&FRA	
Session IV: **Genetic resources information system and germplasm flow for sustainable agricultural production** *Chair:* Dr R.S. Rana, Member, National Biodiversity Authority of India *Co-Chair:* Dr K.C. Bansal, Director, NBPGR *Co-Chair:* Dr Michael Halewood, Bioversity International		
14.00 – 14.30	Who exchanges PGRFA in India and for what purposes	Dr J.S. Sandhu, ADG (Seed), ICAR
14.30 – 15.00	Major patterns of germplasm flows within, into and out of India	Dr Arun Lal, Head, Germplasm Unit, NBPGR
15.00 – 15.30	PGRFA information systems in India and benefits from their use	Dr Sunil Archak, Senior Scientist, NBPGR
15.30 – 16.00	*Tea/coffee break*	
16.00 – 17.00	Bioversity–ICAR–Africa Partnership for germplasm exchange for sustainable agriculture in the context of climate change	Dr Prem Mathur, Bioversity International
17.00 – 17.30	Biodiversity, grassroots green innovations and poverty alleviation: role of institutions, initiatives and incentives	Dr Vipin Kumar, National Innovation Foundation
19.30 – 21.00	*Dinner*	

DAY 3	Wednesday, 25 January 2012	
Session V: **Identifying ways forward** *Chair:* Mr Kent Nnadozie, ITPGRFA *Co-Chair:* Dr Michael Halewood, Bioversity International *Co-Chair:* Mr Gurdial Singh Nijar, Law Faculty, University of Malaya		
09.00 – 09.30	Seeds for life – Action with farmers in Uttar Pradesh – IGP region to enhance food security in the context of climate change	Ms Anne Marie Moeller, HPPI
09.30 – 10.00	Farmers' views on access to germplasm and varieties	Mr Sunda Ram Mr Vikas Chaudhary
10.00 – 13.00	Small group exercises to identify issues and options for implementation of the MLS in India	*Facilitator Group I:* Dr Michael Halewood *Facilitator Group II:* Dr Prem Mathur *Facilitator Group III:* Mr Kent Nnadozie
11.00 – 11.30	*Tea/coffee break*	
13.00 – 14.00	*Working Lunch* – Hosted by PPV&FRA	
Session VI: **Plenary Session** *Chair:* Dr S. Ayyappan, Secretary, DARE and DG, ICAR *Co-Chair:* Dr P.L. Gautam, Chairperson, PPV&FRA		
14.00 – 16.00	Group presentations, discussion and recommendations	
16.00 – 16.30	Workshop evaluation	
16.30 – 17.00	Workshop closing	
17.00 – 17.30	*Tea/Coffee break*	

Appendix 2

LIST OF PARTICIPANTS

Name
Dr S. Ayyappan Secretary DARE and DG, ICAR, Krishi Bhavan, New Delhi - 110001
Dr R.S. Paroda Chairman (TAAS) and Executive Secretary (APAARI), Pusa Campus, New Delhi - 110012
Prof Swapan K. Datta DDG (Crop Science), ICAR, Krishi Bhavan, New Delhi - 110001
Dr T.P. Rajandran ADG (Plant Protection), ICAR, Krishi Bhavan, New Delhi - 110001
Dr J.S. Sandhu ADG (Seeds), ICAR, Krishi Bhavan, New Delhi - 110001
Dr S. Mauria ADG (IP&TM), ICAR, ICAR, Krishi Bhavan, New Delhi - 110001
Dr Sudhir Kochhar National Coordinator, NAIP, KAB-II, Pusa Campus, New Delhi - 110012
Dr Sanjeev Saxena Principal Scientist, ICAR, Krishi Bhavan, New Delhi - 110001
Mrs Smriti Sharan Director (Seeds), Department of Agriculture and Cooperation, Ministry of Agriculture, Krishi Bhavan, New Delhi-110001
Dr P.L. Gautam Chairperson, PPV&FR Authority, NASC Complex, Pusa Campus, New Delhi - 110012
Dr R.C. Agrawal Registrar General, PPV&FR Authority, NASC Complex, Pusa Campus, New Delhi - 110012
Dr D.S. Mishra Registrar, PPV&FR Authority, NASC Complex, Pusa Campus, New Delhi - 110012
Dr Sujata Arora Director, Ministry of Environment & Forests, Paryavaran Bhavan, CGOComplex, Lodhi Road, New Delhi - 110 003
Dr Balakrishna Pisupati Chairman, National Biodiversity Authority (NBA) of India, 5th Floor, TICEL Bio Park, Taramani, Chennai - 600 113
Dr R.S. Rana Former Director, National Bureau of Plant Genetic Resources (NBPGR); and Member, National Biodiversity Authority (NBA) of India, D-43, Indraprashtha Apartments, Sector 14, Rohini, Delhi, India. Email:rairana@vsnl.net
Mr G.S. Yadav Deputy Legal Advisor, Department of Legal Affairs, Ministry of Law and Justice, 'A' Wing, Shastri Bhawan, New Delhi - 110001
Prof Samir K. Brahmachari Director General, Council of Scientific and Industrial Research (CSIR), Anusandhan Bhawan, 2 Rafi Marg, New Delhi - 110001, India New Delhi
Mrs Chandni Raina Director, DIPP, Ministry of Commerce and Industry, Udyog Bhawan, New Delhi - New Delhi 110 107

Name
Dr K.S. Charak Advisor and Head, Environmental Biotechnology Division, Department of Biotechnology, Ministry of Science and Technology, New Delhi - 110003
Dr N.K. Dadlani Director, National Seed Association of India 909, Surya Kiran Buliding, Kasturba Gandhi Marg, New Delhi - 110001, India
Dr Swetaraj kumar Examiner of Patent and Design, Intellectual Property Office, Dwarka, New Delhi - 110075
Dr K.C. Bansal Director, NBPGR, Pusa Campus, New Delhi - 110012
Dr D.C. Bhandari Head, Germplasm Exploration Division, NBPGR, Pusa Campus, New Delhi - 110012
Dr R.K. Tyagi Head, Germplasm Conservation Division, NBPGR, Pusa Campus, New Delhi - 110012
Dr M. Dutta Head, Germplasm Evaluation Division, NBPGR, Pusa Campus, New Delhi - 110012
Dr P.C. Aggarwal Head, Plant Quarantine Division, NBPGR, Pusa Campus, New Delhi - 110012
Dr Arjun Lal Head, Germplasm Unit, NBPGR, Pusa Campus, New Delhi - 110012
Dr Pratibha Brahmi Senior Scientist, NBPGR, Pusa Campus, New Delhi - 110012
Dr Sunil Archak Senior Scientist, NBPGR, Pusa Campus, New Delhi - 110012
Dr Vandana Tyagi Senior Scientist, NBPGR, Pusa Campus, New Delhi - 110012
Dr Suman Sahai Chairperson, Gene Campaign, Lane W-15C-2 (J-235/A) Sainik Farms, Khanpur, New Delhi - 110 062
Dr Vipin Kumar National Innovation Foundation-India, Satellite Complex, Premchand Nagar, Jodhpur Tekra, Satellite, Ahmedabad - 380 015, Gujarat
Ms Anne Marie Moeller
Dr Hari Upadhyaya Assistant Research Programme Director-Grain Legumes; and Principal Scientist and Head Gene Bank, ICRISAT, Patancheru - 502 324, Andhra Pradesh, India
Dr Shivali Sharma Scientist, Genetic Resources, ICRISAT, Patancheru - 502 324, Andhra Pradesh, India
Dr Michael Halewood Head, Policy Research and Support Unit, Bioversity International, Via dei Tre Denari 472/a,00057 Maccarese (Fiumicino), Rome, Italy
Dr Ronnie Vernooy Bioversity International, Via dei Tre Denari 472/a,00057 Maccarese (Fiumicino), Rome, Italy
Dr Prem Mathur South Asia Coordinator, Bioversity International, G-1, B-Block, NASC Complex, DPS Marg, New Delhi - 110012
Dr Bhuwon Sthapit Regional Project Coordinator (TFT), Bioversity International, G-1, B-Block, NASC Complex, DPS Marg, New Delhi - 110012

Name
Mr Gurdial Singh Nijar Law Faculty, University of Malaya 50603 Lembah Pantai, Kuala Lumpur, Malaysia
Mr Kent Nnadozie Senior Technical Officer, International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), FAO, Rome, Italy
Mr Sunda Ram Progressive Farmer, Village and Post Danta, District Sikar, Rajasthan
Mr Vikas Chaudhary Progressive Farmer, Society for Conservation of Natural Resources and Empowering Rural Youth, Chaudhary Anand Parkash Farm, Anjanthali Road, Tararori, Karnal
Mr Manoj Kumar Progressive Farmer, Society for Conservation of Natural Resources and Empowering Rural Youth, Chaudhary Anand Parkash Farm, Anjanthali Road, Tararori, Karnal

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Bioversity International

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Bioversity Headquarters
Via dei Tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome, Italy

www.bioversityinternational.org

Tel. (39-06) 61181
Fax. (39-06) 61979661
Email: bioversity@cgiar.org

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