Agricultural Values of Plant Genetic Resources

Edited by

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Foreword

There is growing international consensus on the urgency of slowing the human-induced deterioration of biodiversity, a deterioration that may be coming at high costs to present and future generations. Indeed, within the United Nations system, the adoption of the International Undertaking on Plant Genetic Resources in 1983, at the Food and Agriculture Organization (FAO), and of the Convention on Biological Diversity (CDB) in 1992, at the Rio Earth Summit, were motivated by the universal goal of achieving a better sustainability and diversity of species and ecosystems. As this Convention also recognized the particular relevance of biodiversity for food and agriculture, the FAO adopted a resolution in 1993 requesting member countries to negotiate (through the FAO Inter-governmental Commission on Genetic Resources for Food and Agriculture) the revision of the International Undertaking in harmony with the CBD. The Third Conference of the Parties to the Convention also decided to establish a multi-year programme of activities on agricultural biological diversity with the goals of: (i) promoting the positive effects and mitigating the negative impacts of agricultural practices on biological diversity in agro-ecosystems and their interface with other ecosystems; (ii) promoting the conservation and sustainable use of genetic resources of actual or potential value for food and agriculture; and (iii) promoting the fair and equitable sharing of benefits arising from the utilization of genetic resources. Benefit sharing is also called for under the International Undertaking's endorsement of the concept of Farmers' Rights, which aims, *inter alia*, to 'allow farmers, their communities, and countries in all regions, to participate fully in the benefits derived, at present and in the future, from the improved use of plant genetic resources'. The CBD Secretariat has agreed to work jointly with the FAO in the implementation of this programme of activities.

In considering the sharing of benefits between providers and users of genetic material, at national and global levels, questions of economic efficiency arise. Unfortunately, the economic benefits associated with the conservation and sustainable use of genetic resources for food and agriculture are poorly understood. In fact, FAO's desire to address this topic area was the impetus for the Economic and Social Department of FAO, in conjunction with the University of Rome 'Tor Vergata', to co-sponsor the Symposium on the Economics of Valuation and Conservation of Genetic Resources for Agriculture in May 1996. The chapters presented in this book were derived from this symposium. The purpose of the symposium was to bring to focus the key issues and to discuss economic instruments that could encourage the implementation of both socially acceptable strategies for the conservation and sustainable use of genetic resources for food and a fair and equitable sharing of the related benefits and costs. I believe that the symposium was particularly timely in addressing these issues only a few weeks before a Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture was adopted in Leipzig, Germany, at the International Technical Conference on Plant Genetic Diversity.

Determining the value (private and public) of genetic resources, and hence the benefit of having more or less of them is by no means a trivial task. The market price of germplasm is not an appropriate indicator of the value, because it does not normally reflect in full all of the actual or potential kinds of benefits derivable from a genetic material: specifically, benefit from current use, benefit from future use options, and benefit from existence *per se*. Under the prevailing market conditions, the price of germplasm captures mainly the so-called *use value* of genetic resources (i.e. the value associated with the direct and indirect benefits resulting from the use of germplasm by farmers and plant breeders). For them, seeds are inputs to more productive or disease-resistant varieties. To a large extent, this use value is a function of the breeding technology and of the income achievable from the productive use of the improved seed. Improvements in breeding technology, for example through biotechnology, will increase breeders' demand for germplasm and thus raise its value and market price. One share of the economic benefits of more successful breeding goes ultimately to consumers in the form of lower food prices and another to farmers in the form of greater revenues due to higher yields.

The second value component, the so-called *option value*, is much less well captured in the market price of germplasm. It reflects the future benefit to the society associated with a reduced disappearance and a better preservation of genetic resources for future needs of breeders. In other words, the option value reflects the economic benefit of avoiding irreversible decisions which would limit the options for breeders in the future. The market price of seeds and germplasm is not a good indicator of this value component because, for a number of reasons, there is only a limited current market demand for such future use options. Unless appropriate institutions are established, those who would have to bear the consequences of reduced future agro-biodiversity are not well represented in today's markets for germplasm exchange.

Theoretically, there could be a third component of the value of genetic resources, the *existence value* (i.e. the value of ensuring the survival of a species, variety or breed just for its own sake or for some moral reason). While this may be the case for some rare animal breeds which people wish to keep just for their beauty, such existence values are likely to be of little practical relevance for the plant genetic resources of interest to food and agriculture. But reference to this value category is made mainly to illustrate the complexity of the valuation problem.

From an economic standpoint, one of the key issues is how to factor uncertainty into the estimation of benefits and costs of programmes for maintaining agro-biodiversity. Uncertainty in this case regards the possibility of acquiring better information about future consequences of erosion of agro-biodiversity over time. If such information is forthcoming, there is a value on those initial actions that preserve future flexibility and a cost on those which reduce flexibility, because the latter precludes the exploitation of the additional information at a later date. If a society takes measures to halt the erosion of agro-biodiversity now, and, subsequently, future generations place a low value on the greater agro-biodiversity, it will still be possible to revert to the old practices that were more harmful for biodiversity. But if no measures are taken now and the genetic resource base is allowed to deteriorate, it will be too late to act if it is subsequently discovered that future generations depend and place a higher value on agro-biodiversity. In other words, there is a premium associated with actions that preserve flexibility.

This flexibility premium is another term for option value or quasi-option value of maintaining a sufficiently large biodiversity. Ultimately this premium will manifest itself through greater stability and/or more rapid growth of agriculture and through the ability of breeders to respond to yet unknown human needs for food quality and safety. To avoid undervaluation of genetic resources for food and agriculture, this flexibility premium must be part of the total economic valuation.

Examples abound of other issues for which economic analysis may aid the decision maker. For instance, considering that some genetic resources are more in need of conservation than others, and, certainly, some geographic regions are more important sources of germplasm than others, what are the criteria for decision making? If numerous communities have basically the same genetic resources, is conservation advisable in all of them or just in a few, and what are the appropriate actions to be taken? Can existing, or new *sui generis* systems of intellectual properties' rights, including farmers' rights, be formulated in such a way that these questions are answered through some sort of a market mechanism?

I have attempted to raise only few of the many questions that need to be answered if action on the conservation and more sustainable use of agro-biodiversity is to be taken seriously. In a more comprehensive fashion, *Agricultural Values of Plant Genetic Resources* should help the reader to become informed about some of the key issues involved in the economics of the valuation and conservation of genetic resources of interest to food and agriculture. These chapters demonstrate that, while research on the economics of this subject is in its infancy and measures of the economic benefits are uncertain, economics can provide insights on this subject that can be useful to the policymaker.

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Abbreviations

ARBN	Asian Rice Biotechnology Network
ARS	Agricultural Research Service
BPH	brown plant hopper
BSE	bovine spongiform encephalitis
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CGR	crop genetic resources
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	International Maize and Wheat Improvement Centre
CIRAD	Centre de Cooperation Internationale en Research Agronomique pour le Developpement
COP	Conference of the Parties to the CBD
EMBRAPA	Empresa Brasiliera de Pesquisa Agropecuaria
ENEA	National Agency for Alternative Energy
FAO	Food and Agriculture Organization
GATT	General Agreement on Tariffs and Trades
GEM Project	Germplasm Enhancement Maize Project
GEU	genetic evaluation and utilization
HPR	host plant resistance
HPT	host plant tolerance
HYV	high-yielding variety
i.i.d.	independent and identical distribution
IARC	international agricultural research centre
IBPGR	International Board for Plant Genetic Research
ICRISAT	International Crops Research Institute for the Semi-arid Tropics

IITA	International Institute of Tropical Agriculture
INGER	International Network for the Genetic Evaluation of Rice
IPF	invention possibilities frontier
IPGRI	International Plant Genetic Resources Institute
IPP	international plant protection
IPRs	intellectual property rights
IRG	International Rice Genebank
IRGC	International Rice Germplasm Collection
IRPB	IRRI plant breeding programme
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
LAMP	Latin American Maize Project
MV	modern varieties
NARS	national agricultural research system
NGO	non-governmental organization
NMS	nuclear male sterility
NPV	net present value
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
PGR	plant genetic research
PGS	Plant Genetic Systems
PVP	plant variety protection
R&D	research and development
RPA	research problem area
RT	research technique
SFN	search field narrowing
2SLS	two-stage least squares
SPD	subjective probability distribution
SPE	subjective probability estimate
SSR	simple sequence repeat
TD	technological determination
TFP	total factor productivity index
TRIPS	trade-related aspects of international property rights
UNCED	United Nations Conference on the Environment and Development
UPON	Union for the Protection of New Varieties of Plants
USDA	United States Department of Agriculture
WARDA	West Africa Rice Development Authority

Introduction and Overview: Agricultural Values of Plant Genetic Resources

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Plant genetic resources (PGRs) can be classified into two broad groups. The first group is made up of the genetic resources within the cultivated species. These include the 'landraces' or 'farmer varieties' selected by farmers over many generations and 'tailored' to different producing environments. Also included in this group are the wild species and wild relatives of the cultivated species. The value of this first group of PGRs for plant breeding is well recognized and reflected in the investments made to collect, evaluate and conserve these PGRs in *ex situ* gene bank collections.[1]

The second group of PGRs encompasses the genetic resources from other plant species (and, in practice, even from species outside the Plant Kingdom). Until the development of modern 'biotechnology' techniques, this group of PGRs was not valued for plant breeding use. With the development of methods for transforming DNA (and gene-controlled traits) from 'alien' species into economically valuable plants, this second group takes on potential plant-breeding value.

Interested parties have supported the collection and preservation of both groups of PGRs. Until recently, these interests have not been closely allied. Agricultural research programmes and plant-breeding programmes, as noted above, have supported the collection, preservation and evaluation of PGRs of the first group for many years. For most major crop species, a high proportion of potentially valuable landrace and their wild-weeding relatives are in gene bank collections (see Table I.1). The parties interested in preserving the second group (i.e. the non-cultivated species) of PGRs are motivated by broader concerns associated with maintaining the 'biodiversity' of all species. They support *in situ* collections, and the maintenance of natural preserves and natural habitats.

Table I.1. Genetic diversity collection and utilization by commodity.

							Ex situ						
	Area (Mha)	Landraces (× 1000)	% in collections	Wild species	% in collections	*In situ* collections	Major collections (× 1000)	Accessions (× 1000)	% CGIAR	% Dup.	% I.R	% WS	Utilization distribution
Commodity													
Bread wheat			95	24	60	Few	24	784	16	50	17	2	
Durum wheat		150	95	24	60	Few	7	20	14	32	53		High
Triticele			40				5	40	38	66			
Rice	149	140	90	20	10	Few	20	420	26	75	25	1	High
Maize	130	65	90		15	Few	22	277	5	80	16	0	High in LDCA
Sorghum	43	45	80	20	0	Few	19	169	21	42	18	0	Low
Millets	38	30	80		10	None	18	90	21		33	2	Low
Barley		30					16	484	5	23	9	1	
Oats							20	222	0		1	4	
Rye							8	287	0		8	0	
Food legumes													
Beans			50		70	Few	15	268	15	76	21	1	Low–medium
Soybeans	66	30	60			None	23	174	0	?	2	1	Low–medium
Chick peas					75		13	67	41	75	29	1	
Lentils					95		5	26	30	95	30	3	
Fava beans					25		10	29	33	35	42	0	
Peas					0		18	72	0		4	0	
Groundnuts		15			28		16	81	18	28	15	1	
Cowpeas					30		12	86	19	30	19	2	
Pigeon peas					22		4	25	52	22	50	2	
Lupin							10	28	0		12	16	
Root crops													
Potato	19	30	95		30	Few	16	31	20	100	13	5	High
Sweet potato	10	5	50			Few	7	32	21	93	16	6	Medium
Cassava	16		35		29		5	28	30	90	23	2	Low–medium
Yam		3					2	12	25	20	24	0	
Sugar cane		20	70										

The two interest groups are finding more common interests in recent years (and are resolving conflicting interests as well). This is in part due to improved awareness by the biodiversity interests in the history of conservation of PGRs by agriculturalists. It is also in part due to a recognition by both interest groups that valuing PGRs is important to conservation–preservation policy. The biodiversity interests have traditionally stressed 'existence' values and 'biophilia' values in support of policies. They are increasingly recognizing that the 'hard' economic values associated with plant improvement provide important additions to their policy arsenals. Agriculturalists, by the same token, are also stressing their own broader conservation interests and are beginning to expand their perception of usable PGRs as new biotechnology techniques come into use.

This volume is addressed to the assessment of economic value for PGRs. The focus of attention for chapters attempting actual value estimates is on the first group of PGRs (i.e. the cultivated species), but two chapters do deal with the implications of biotechnology (and both argue that the new biotechnology methods endow non-cultivated PGRs and other PGRs with plant breeding value, but not at the expense of value for the cultivated PGRs). The estimation of PGR values is a relatively new field of inquiry for economists and this immaturity is no doubt reflected in the papers in the volume.

The volume is organized in five parts and includes 19 chapters. Part I (Chapters 1–4) covers models of value of PGRs. Part II (Chapters 5 and 6) covers empirical studies of PGRs, field diversity and yield vulnerability. Part III is the core of the volume. It includes seven empirical studies of PGR values. Most of these studies associated PGR values with 'genetic trait' values associated with PGRs. One chapter (13) reports a 'breeding production function' study. Part IV addresses the issue of property rights in PGRs. These are important because they provide incentives for collection and preservation of PGRs and because they endow PGRs with value. The final part includes two chapters addressing the implications of modern biotechnology methods for PGR values.

In this introduction we discuss three topics that pervade the volume. These are valuation concepts, plant breeding institutions and valuation methods. We then provide a brief overview of the chapters in the volume.

Activities (Investments) and Values

Economists make a distinction between *use* and *non-use,* or existence, value. Table I.2 depicts relationships among activities or investments and four types of use values and non-use values. The activities associated with PGRs require real economic resources or investments and each of these activities is designed to add economic value to them. It is important to note that the 'natural' value of PGRs (e.g. the value of farmers' rights) is the value of the final product (e.g. a new variety of rice) minus the valued added by each activity.

Our main concern in this volume will be with the direct use value of PGRs for breeding. We will also be concerned with the indirect use option value