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# Agrobiodiversity: Dynamic Change Management

## Introduction

Agrobiodiversity has developed as a result of natural selection and human intervention. Its conservation and sustainable use is essential for the survival of humankind. Besides its supporting role in the risk management of millions of smallholder farmers around the globe by assuring their survival and livelihood, it is an important key for adaptation of agriculture to a future changing environment, especially in terms of climate change and diseases. During the past few decades, agrobiodiversity has decreased at an alarming rate and losses are increasing rapidly in the areas where it has often been very rich. Modernization and intensification, mechanization and monoculture, lack of knowledge and incentives for conservation have reduced access to genetic resources and their free use; and other processes of social and economic change have affected agrobiodiversity. As the world is dynamic, the need for diversity is continuous and increasing owing to the increasing number of people to be fed, kept warm, housed and cured.

The world landscape and biodiversity profiles are changing fast with forest shrinkage, agricultural lands shadowed by ambitious urban and peri-urban developments, genetic vulnerability of crops, genetic erosion on account of greater spread of high-yielding varieties and threat of climate change. In three centuries (1700–2000) there has been more than a 500% increase in the area under agriculture, with corresponding global forest reduction of over 20%. Almost a 100 million ha increase in agricultural land has occurred in just two decades (1980–2000), of which around 55% has been added from forest cover (FAO, 1967, 1998, 2010).

Exponential population increase and demand for more food, feed and fibre have been the main causes of over-exploitation of natural resources. Every morning the world wakes up to a demand for food for an additional 200,000 people. Globally, half of all food produced comes from 1.5 billion smallholder farmers. Subsistence farmers depend mainly on landraces in their cropping systems and they use nearly 60% of the total agricultural land. Hence, making smallholder farmers aware of conservation and rational use of agrobiodiversity is a critical prerequisite for global sustainable development. In fact, time is running out, and 'business as usual' will not suffice to salvage the rich genetic diversity that is being eroded due to human intervention and climate change. In the process of development, as well as depletion of natural resources, we are on the verge of losing, or have actually lost, valuable agrobiodiversity in different regions. Unfortunately, such realization often comes too late to reverse the process. We have hardly done what is needed for both conservation and replenishment of natural resources (Paroda, 2016).

During the UN Conference on Environment and Development (UNCED) in 1972 in Stockholm, various nations started thinking of inter alia care to protect agrobiodiversity landscapes and to conserve and use dynamic gene pools of agricultural species and their wild relatives for overall sustainable development. In 1983, the UN FAO provided a non-legally binding platform as per the International Undertaking on Plant Genetic Resources (IUPGR) to act locally on the principle of 'germplasm is the common heritage of humankind', to maximize international free flow of germplasm and its use in crop improvement. Subsequently, the Convention on Biological Diversity (CBD) in 1992, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) in 2001 and the Nagoya Protocol on Access and Benefit Sharing (NP-ABS) in 2010 set legal standards for facilitating access and benefit sharing. This arrangement, although ratified by many countries, has halted the use of genetic resources to a great extent (FAO, 1998, 2010, 2011).

However, the responsibility of implementing conservation, and access and benefit sharing (ABS), is broadly left to countries without much international commitment. Nevertheless, actions at the local and regional level are crucial to harness desired genes/attributes for better adaptability, fitness and higher source-sink relationship from available gene-rich agrobiodiversity. Inescapable interdependence of countries and people around the world in terms of meeting one another's needs, preferences and tastes has significantly changed our food baskets. Therefore, it is important and urgent to manage and maintain at least the current level of genetic resources, and for this, new, innovative approaches, ways and means need to be properly planned (FAO, 1983; Paroda, 2016).

## Agrobiodiversity Conservation

Agrobiodiversity dates back to the settlement and domestication era, over ten millennia BC, whereas the centres of origin and diversity of crop plants were conceptualized only in the past century, mainly in the late 1920s. The knowledge regarding centres of origin and richness of available genetic resources and evolution of technological approaches for germplasm use over the past nearly six decades did have a paradigm change for agricultural research from direct selection to systematic plant breeding and use of biotechnology. Again, it is well argued that while the importance of agrobiodiversity and genetic resources has to be understood globally, the specific actions to conserve and protect them for posterity will also have to be managed locally. Hence it is critical to make efforts to minimize the gap between needs and developments relating to agrobiodiversity management at global, regional and national levels. Bigger countries with diverse agro-ecologies have to focus greater attention on the zonal level also (Scarascia Mugnozza, 1995; Bala Ravi *et al.*, 2010).

### Global initiatives

The widespread genetic resource collection efforts in the 1950s across the world, followed by the establishment of national gene banks for *ex situ* conservation of seeds of plant germplasm, led to the beginning of the plant genetic resource (PGR) conservation movement in the 1960s (FAO, 1967). The change management around genetic resources for food and agriculture (GRFA), as contemplated by the international agencies, especially the Food and Agriculture Organization of the United Nations (FAO), helped investment in PGR management and institutionalizing processes for collecting available diversity to be conserved and used by farmers in the future and to meet existing crop breeding needs across the world. It is also appropriate to pay tribute to the international community of farmers who shaped agrobiodiversity through their conscious selections and subconscious interventions over generations; and also to pioneers like Albert and Gabriella Howard, N.I. Vavilov, B.P. Pal, Sir Otto H. Frankel, E. Bennett, R.O. Whyte, J.G. Hawkes, J.H.W. Holden, J.T. Williams, and many others who shaped or joined the global germplasm movement for agrobiodiversity augmentation, conservation and use (Frankel and Bennet, 1970; Frankel, 1975; Harlan, 1992; Paroda, 2016).

The global mechanisms led by the FAO and the Consultative Group on International Agricultural Research (CGIAR) successfully catalysed and nurtured the germplasm conservation movement. In the process, the CG centres, including Bioversity International (BI), which emerged from the erstwhile International Plant

Genetic Resources Institute (IPGRI), the earlier International Board for Plant Genetic Resources (IBPGR) and other CG centres like the International Rice Research Institute (IRRI), International Maize and Wheat Improvement Center (CIMMYT), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), International Center for Agricultural Research in the Dry Areas (ICARDA), International Centre for Tropical Agriculture (CIAT), International Food Policy Research Institute (IFPRI), International Livestock Research Institute (ILRI), International Institute of Tropical Agriculture (IITA) and International Potato Center (CIP) laid considerable emphasis on sharing and using available agrobiodiversity resources for much-needed genetic enhancement for yield, stress tolerance and quality. In the process, both *ex situ* and *in situ* on-farm approaches were aggressively promoted (FAO, 1983; Paroda, 2016).

As regards sustainable use of plant genetic resources (PGRs), held *ex situ* in CG gene banks and *in situ*/on-farm in farmers' fields in diversity-rich areas, the process for multilateral access of the GRFA with equal emphasis on Farmers' Rights was triggered through the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The FAO Working Group defined and adopted a definition of farmers' rights, agreed to the creation of a gene fund and finalized the list of 64 crops (incorporated as Annex 1 of the treaty). Also, an important initiative was taken to establish a Global Crop Diversity Trust (GCDT). During the first global conference, organized by the Global Forum on Agricultural Research (GFAR), the forum came out with a Dresden Declaration on Biotechnology and Management of Agrobiodiversity. All these initiatives culminated in a long-term, safe collection of genetic diversity available with all CG centres, and the FAO designated collections for multilateral access under the ITPGRFA, conserved in a permafrost facility at Svalbard, created by the GCDT (Gepts, 2004; Paroda, 2012, 2016).

The FAO initiatives, through first and second technical reports on the 'State of the World's Plant Genetic Resources', and subsequently the 'State of the World's Animal Genetic Resources', also catalysed different National Agricultural Research Systems (NARS) in many parts of the world to initiate national action plans for managing genetic resources. At the same time, the World Information and Early Warning Systems (WIEWS) and many CG centre gene banks organized and provided valuable information on the GRFA relating to plants, animals, fish, insects and microbes, which drew needed attention for scientific evaluation, conservation and use.

While initiatives in the context of agrobiodiversity conservation, management and use were significant, some other major initiatives taken worldwide by different nations included putting in place their plant variety protection or *sui generis* systems to harmonize with a global WTO Trade-Related Aspects of Intellectual Property Rights (TRIPS) regime. In the process, germplasm exchange at the national, regional and global levels received a setback, mainly owing to uncertainties arising from issues like access and benefit sharing (ABS), determination of mutually agreed terms (MATs) and material transfer agreements (MTAs), ensuring effective protection and enforcement of IPR. Public awareness of these issues and institutional capacity to handle them became more prominent concerns. In many cases, the processes for sharing of genetic resources, even for research or direct human welfare, got complicated, with more and petty legal issues concerning IPR-ABS domains being flagged every now and then (Gepts, 2004; Paroda, 2016).

The institutions responsible for implementing biodiversity and *sui generis* IPR laws resorted to more and more awareness-creating activities, and consequently finding solutions to conflicts on a real terms basis did not get much priority. As a result, the ongoing processes and speed of germplasm exchange and benefit sharing were affected adversely. This trend for relatively slow or even no movement of germplasm, otherwise so critical for genetic advancements in various crop plants and animal species, needs to be reversed with a determined international push and appropriate financial commitment for germplasm enhancement and use at local levels.

## Regional initiatives

Major regional initiatives on germplasm exchange and use were undertaken by most of the CG centres, located in different regions, mainly in view of their core activity as well as their major mandate for accelerated pre-breeding activities in different mandated crops/species. In the process, significant progress took place, including realization of the Green Revolution in South Asia. These developments over the last 50 years catalysed faster agricultural growth and ensured poverty reduction and increased food security in all regions. The CG centres also facilitated networks of germplasm exchange, benefitting mainly weaker NARS, thus ensuring availability of international public goods in the form of new high-yielding varieties and hybrids. In the process, some regional associations like the Asia-Pacific Association of Agricultural Research Institutions (APAARI), the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA), the Forum for Agricultural Research in Africa (FARA) and the Central Asia and Caucasus Association of Agricultural Research Institutions (CACAARI) were actively involved in facilitating such networks in partnership with various NARS of respective regions. APAARI worked closely with Bioversity International (earlier IPGRI) in establishing three sub-regional networks on genetic resources – in south Asia, south-east Asia and the Pacific. APAARI and CACAARI accelerated the process of germplasm exchange and strengthened national gene banks in developing countries' NARS, including adoption of the Suwon Declaration on Agrobiodiversity Management in the Asia-Pacific region, which laid a clear road map for action by all stakeholders. Unfortunately, most of these networks are currently non-functional, mainly due to funding constraints and lack of commitment by the CG centres. Also, pre-breeding initiatives seem to have become casualties at most of the crop research centres in the process of funding through CGIAR Research Programmes and lack of core funding under windows 1 and 2. Even a scoping study of BI to focus mainly on *in situ* conservation strategies seems not to have received due priority for a stand-alone CRP by the CGIAR. Thus, the whole process of agrobiodiversity management has received a setback during the past two decades. It is high time that the whole issue of retarded exchange and use of agrobiodiversity across the regions is revisited, to correct priorities and encourage changes to management of valuable agrobiodiversity, so critical for the future sustainability of global agriculture (Williams and Holden, 1984; Paroda, 2016).

## National initiatives

In India, the process of identifying, assessing and augmenting landrace diversity of amber wheat and other crops, especially in the Indo-Gangetic plains (Howard and Howard, 1911), had started a century ago, mainly by economic botanists, resulting in single plant selections of best amber grain quality Pusa wheat varieties (Pusa 4, 6, 12 etc.), which served a useful cause subsequently as donors for grain quality. For example, use of Type 8A and 9D selections in the early 20th century resulted in breeding popular varieties like C591 in the 1930s and C306 in the 1960s. During the 1940s, plant breeding efforts were accelerated through the rational use of agrobiodiversity by B.P. Pal, as narrated in his famous article 'The search for new genes' (Pal, 1937, 1942). Subsequently, the dedicated efforts of pioneers like Harbhajan Singh, M.S. Swaminathan, A.B. Joshi, K.L. Mehra, R.S. Paroda, R.K. Arora, R.S. Rana and K.P.S. Chandel led to the establishment of a unique institutional mechanism by the ICAR called the National Bureau of Plant Genetic Resources (NBPGR), which is one of the most prominent national genetic resource management systems in the world, with the most modern gene bank facility inaugurated in 1996 and built with funding support from the USAID. Having a current holding of 0.43 million seed accessions and a genebank capacity of 1 million for long-term storage, the NBPGR genebank also has cryo- and *in vitro* gene banks and a network of active collections in medium-term storage modules and field collections in different parts of the country. Lately, the genomic resources have been augmented, and the system is supported by ICAR's world-class computing system to develop the field of bioinformatics. Later, a network of national-level genetic resource bureaux for animals, fish, agriculturally important micro-organisms and insects was created. Concurrently, to provide the opportunity for agricultural scientists and other stakeholders to come together from across the globe and deliberate about agricultural research for development (AR4D) under one roof, the National Agricultural Science Centre (NASC) complex was built in New Delhi. This complex in Pusa Campus also houses regional or Indian offices of various CG centres, the Centre for Agriculture and Biosciences International

(CABI) and important national authorities – the National Rainfed Area Authority (NRAA), the Protection of Plant Varieties and Farmers Rights Authority (PPV&FRA), the National Academy of Agricultural Sciences (NAAS) and the National Agricultural Science Museum. The complex houses an international guest house, an auditorium, boardrooms, meeting halls and lecture halls, and boasts splendid lawns (NRC, 1972; IBPGR, 1986; Paroda, 2016).

The national germplasm management system was started as a Plant Introduction Unit of the IARI, headed by H.B. Singh, which gradually expanded its activities under the guidance of M.S. Swaminathan and A.B. Joshi and developed into an ICAR institute, the NBPGR (NBPGR, 2000). The private seed industry was given an initial boost through these germplasm introduction efforts since the 1950s, and public policy support under the New Policy on Seed Development in 1987, which provided access to breeder seed of varieties and hybrids, developed by the public research system – ICAR institutes and SAUs.

### Regulatory domain

In the post-CBD era, the ITPGRFA holds the key to the system of multilateral access and benefit sharing (MLS) for crop germplasm of identified food, forage and other agricultural species among contracting parties. However, the national biodiversity laws were mainly enacted in harmony with the CBD. Thus, currently there are many grey areas in these laws, particularly with regard to prescribed procedures and processes for germplasm flow of food and agricultural commodities, which require further attention by legislators, regulatory agencies and the executive machinery of governments. Not only corrective steps and their simplification are needed, but also expansion of the scope of the ITPGRFA beyond the Annex 1 coverage at national level, depending upon their strengths in other commodities, trade and commerce, or for sustainable food and nutritional security. Thus, further means and processes to improve access to PGRFA for use in breeding, research and training must be addressed by the national systems. For this, national institutional capacities will have to be developed further, national focal points elaborated and explained to stakeholders, and promotional activities supported and financed as a matter of national priority. For effective implementation of the multilateral system of access and benefit sharing at country level, regulatory authorities must publish literature with explanatory notes to help candidate beneficiaries and potential stakeholders in meeting a number of core and/or supplementary requirements. The elaboration of such requirements needs to be clearly spelled out in the prescribed procedures and processes under the treaty as well as laid out according to the needs of the respective countries. In India, some steps have already been taken in this direction. The government has notified that there is no need to seek prior permission from the NBA by foreign applicants accessing germplasm materials covered under the ITPGRFA. Similarly, guidelines for the implementation of the provisions of access and benefit sharing under the Nagoya Protocol have been notified to implement the Protocol in letter and spirit. However, the implications of the relevant gazette notifications by the Ministry of Environment, Forests and Climate Change must be clearly understood in conjunction with other relevant laws in a case-specific manner to avoid undue litigation or public mistrust (Gepts, 2004; Paroda, 2016).

To encourage countries to adopt measures for the smooth implementation of the ITPGRFA, the governing body of the treaty should also recommend to the FAO that it recognizes and highlights/documents the specific national contributions of countries in the international collections already in circulation by the international centres and national systems for public and private use, through multilateral exchange under the Standard Material Transfer Agreement (SMTA). This arrangement may eventually help in developing and adopting some good, long-term benefit-sharing arrangements among gene-rich and technology-rich countries as well as farmers and innovators.

### Understanding dynamism

In 1993, the Indian Society of Plant Genetic Resources (ISPGR) Dialogue for National PGR Policy Options was held in New Delhi, which commemorated the establishment of the CBD. It emerged that the CBD had drawn as much attention to the need to institutionalize ABS as had the conservation of biodiversity through *in situ* means for sustainable use. The *ex situ* collections were being mainly covered by the FAO global system under the International Undertaking on Plant Genetic Resources (IUPGR), which subsequently was governed under the ITPGRFA. Thus for ABS matters, it would be critical for countries to link these with both the CBD and the ITPGRFA domains (FAO, 1986; Paroda, 2016).

Now that the global debate on conservation and sustainable use of PGRFA has partly settled under the ITPGRFA, it is high time that the regulatory regimes at national level are voluntarily reviewed in the interests of peace and prosperity through agriculture. At this stage, the greatest tributes go to Nobel Peace Laureate Dr Norman E. Borlaug, due to whom agriculture was seen as the most potent sector responsible for sustainable peace on earth. His critical breeding and selection strategy in wheat had led to the greatest ever Green Revolution. Indians and agricultural scientists in particular will always feel proud to portray him as a member of their fraternity and his name is associated with countless commemorations in south Asia (FAO, 1986; Paroda, 2016).

In the past, the Indian National Agricultural Research System had strong national breeding programmes in many crops, which included national crossing blocks, regional cooperative trials by the ICAR institutes and SAUs and/or multi-location testing for identification of superior varieties under the All India Coordinated Research Projects (AICRPs), on almost all crops for food and agriculture. Several improved varieties and hybrids were developed under these projects using native or exotic germplasm without restriction. At present, most of the national programmes seem to have become dependent on the pre-breeding materials provided and/or international nursery trials constituted by many of the international centres/institutions. To rebuild national capacities in enhancement of GRFA and to enhance probabilities of generating more diverse international commons through collaborative research, more participatory activities within and across regions are to be organized and financially supported. Innovation must be encouraged and rewarded in the first place to push the global AR4D agenda for farmers' welfare–development paradigm (Paroda, 2016).

The CBD relates to all components of biological diversity that broadly concern all sectors (health, industry, agriculture, rural development etc.), but PGRFA are of immediate necessity for food and nutritional security and the well-being of humankind. These must receive priority and fast-track handling by regulatory bodies. The issue of farmers' rights raised under the IUPGR is equally important. Both these concerns remained 'outstanding issues' at the time of finalizing the text of the CBD. Accordingly, these two issues had to be renegotiated, which took over seven years to settle in the form of the ITPGRFA. There was no consensus for the definition of farmers' rights and other definitions provided under the treaty. In the FAO Working Group on Farmers' Rights, it emerged that not only plant breeders should have rights over new varieties developed by them but also farmers over the varieties evolved and perpetuated by them. Eventually, farmers' rights became part of the international law under ITPGRFA and India became the first country to internalize it in its legal and policy systems. Many other developing countries look to the Indian experience in this regard with a view to develop their own national systems. The International Agrobiodiversity Congress (IAC) 2016 has provided the opportunity for other countries to share information arising from such developments in the agrobiodiversity domain (Paroda, 2016).

## Change we must for facilitated ABS

Studies clearly show how nations have historically been dependent on one another for diversification of their food baskets or meeting their needs for genetic resources for the increased productivity of agricultural commodities. This dependence is predicted (Galluzzi *et al.*, 2016) to increase more in the future, given the current trends of climate change and the need for an expanding food basket with consumers' preferences for more healthy foods. Therefore, future determinations about how access is to be provided, and what benefit sharing will be agreed upon, will hold the key to sustaining interdependence; and a judicious interpretation of international and national legal obligations and processes under which exchange is to be governed will dictate terms. In this context, administrative, structural and political compulsions are not uniform across countries; and this has rendered the exchange of agro-bioresources/PGRFA much more complex and sometimes uncertain.

Instead of easing the process of facilitation, the ITPGRFA has indirectly led to reduced exchange of germplasm between nations, despite clear recognition of a multilateral system for exchange. Now the Nagoya Protocol of the CBD has increased the complexity in handling situations. Experience shows that the MLS has not functioned at the anticipated level, nor has it helped in generating financial benefit through the proposed international Benefit Sharing Fund (BSF). In India, there is still debate concerning exchange of germplasm, even with local private seed sector organizations engaged in plant breeding. Even SMTA has not yet been put into practice for want of procedural clearance and understanding. ICAR as a policy allowed free access to parental lines of hybrids bred by the public system since the mid-1980s, recognizing that seeds of these hybrids would otherwise not reach end-users, i.e. smallholder farmers. This policy decision accelerated the coverage of hybrid seeds resulting in increased crop productivity and helped strengthen the existing Indian private seed sector. With the pronouncement of plant variety protection and the rise of IPR regimes in agriculture and biotechnology, there is hesitation in the developing countries to share their germplasm accessions due to uncertainties and fears over possible effects of ABS and IPR. There is a definite lack of much-needed trust and partnership. A kind of fatigue has jeopardized agricultural growth. This will require an enabling policy environment to foster sharing of germplasm as well as information between the public and private sectors (Swaminathan, 2002; Paroda, 2016).

In many cases, farmers are custodians of traditional varieties in different diversity-rich regions. In India, their rights are now being protected under the *sui generis* PPV&FR Act. The system of genome saviour awards and recognition has evolved considerably with government funding, and farmers are being made aware through ICAR's *Krishi Vigyan Kendras* (Farm Science Centres) and extension units of SAUs. The PPV&FR Authority needs to be commended for implementing farmers' rights and creating awareness. The Authority has been assured of government support to build an Indian gene fund of Rs 500 million (around US$7.5 million) to ensure long-term recognitions, rewards and incentives to farming communities engaged in conserving valuable genetic resources. It is also expected that the evolution of benefit-sharing mechanisms along with funding support from the seed sector will help in building up the gene fund to around US$20 million in the future. Simultaneously, there is a need to develop a clear mechanism to benefit farmers directly for their invaluable service regarding PGRFA to society (FAO, 1997).

## Turning Youth into Catalysts of Change

Rural youth are undoubtedly the key to food security, agricultural sustainability and innovation in farming. Yet few youths in villages see a future for themselves in agrobiodiversity management, agriculture or farm enterprise. The declining interest among rural youth in agriculture is directly related to existing poor physical amenities, socioeconomic conditions and lack of an enabling environment. Economic factors like low-paid employment and inadequate credit facilities discourage them from remaining in agriculture. It is clear that for sustainable rural development to occur, young farmers, especially smallholders, must be at the centre of all policy decisions, which can be handled at local level. Funding from central government should be made available to reach rural youth with the right message and viable options. Concerted efforts are needed to equip them with technology, innovation and market-linked facilities.

Some imperatives for sustainable agrobiodiversity management in gene-rich rural areas are: safeguarding of available natural resources; sharing available knowledge (both traditional and formal); building local PGRFA inventories, local access processes and capacity to harmonize with existing policies and laws; promoting conservation for sustainable PGRFA use; and developing links and partnerships at local, district, state and country levels (Paroda, 2016). Rural youth must be sensitized, trained and supported to the level of sustainable self-dependence to manage dynamic agrobiodiversity.

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