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Enhancing Biodiversity Through Market-Based Strategy: Organic Agriculture

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Abstract

The diversity of plant genetic resources (PGR) from which the world’s food crops are derived is steadily declining, due in part to the reliance of modern agriculture on a limited number of improved varieties. This erosion of genetic variation can lead to increased vulnerability to plant pests and diseases as well as to the potential loss of future varieties that will be required to meet the challenges brought about by climate change. Having recognized that the protection and sustainable management of PGR is critical to ensuring food security and alleviating poverty, governments and the international community have used public funds to establish seed banks and protected areas in an effort to preserve the existing PGR. However, given their small scope and susceptibility to genetic drift, the effectiveness of these public efforts may be limited. The vast majority of remaining PGR diversity is in the hands of smallholder farmers in remote areas of developing countries who cultivate a wide array of traditional varieties. This paper argues that a comprehensive system of market-based incentives is necessary to ensure that smallholder farmers continue to conserve plant genetic resources. Promoting certified organic agriculture has emerged as one of the most promising market-based development strategies for protecting PGR diversity. By providing incentives in the form of premium prices as a form of payment for environmental services, farmers are encouraged to adopt sustainable cultivation of local varieties and thus maintain high levels of biodiversity, without a burden on public expenditures.

JEL Classification: Q57, Q27, Q56

Contents

1. INTRODUCTION

The protection and sustainable management of biodiversity, in particular plant genetic resources (PGR) is crucial to achieving Goal 7 of the Millennium Development Goals (MDG). Specifically, target 9, which integrates the principles of sustainable development into country policies and programs and aims to reverse the loss of environmental resources. The protection of PGR is crucial to the adaptation of the agriculture sector as PGR declines worldwide due to changes in land use, land degradation, monocrop practice in intensive agriculture, pollution, contamination by genetically engineered genes, and other environmental changes. According to the Plant Conservation Report, two-thirds of the world's plant species are in danger of extinction with pressure from the growing human population, habitat modification and deforestation, over-exploitation, the spread of invasive alien species, pollution and the growing impacts of climate change (Convention on Biological Diversity 2009). Policy makers are now becoming more aware that the decline of PGR will reduce the ecosystem's ability to produce food, resist pests and diseases, and withstand the stress brought about by climate change.

The remaining PGR are preserved in limited areas such as ecological reserves and other protected areas under public funding. However, since such systems are very costly, to date, no country has put in place a comprehensive system to protect its PGR. Apart from PGR being preserved under public funding, another often-forgotten source is the PGR being protected by poor farmers practicing traditional farming, largely in the remote marginal areas of developing countries. With globalization and rapid infrastructure development in developing countries, these marginal areas are rapidly opening up and traditional farming systems are being transformed into commercial systems based on monocrop cultivation of high-yielding varieties, leading to rapid decline of PGR. While poverty reduction through modernization of farming systems is imminent, alternative agriculture development strategies to enhance and preserve PGR must be identified. Priority should be given to market-based strategies that can achieve a sustainable and wide scope of impacts.

This paper reviews issues associated with PGR and discusses organic agriculture as a possible alternative development strategy to preserve the PGR now being protected by poor farmers. Part 2 introduces the value and importance of genetic diversity in PGR. It also explains the causes of its rapid erosion, its vulnerability, and the threat to biodiversity of global climate change, and the consequences of its erosion.

Part 3 is a presentation of current ways of preserving PGR and shows how small farmers can make a contribution to gene bank preservation. It describes how smallholder farmers and communities have the capacity to help preserve landraces and traditional plants—rich in rare and useful genes—thanks to their indigenous knowledge of the management of landraces and their technical skills in seeds conservation. It concludes with a description of the ways in which partnerships between farmers, research institutes and the public sector could be very relevant to ensuring a safe preservation of remaining diversity.

Part 4 introduces certified organic farming as a tool for protecting PGR and shows how this practice can encourage smallholder farmers to fulfill their important role of protector of the richness of the genes contained in landraces and traditional plants through market-based incentives.

2. USEFULNESS OF AND THREATS TO PLANT GENETIC RESOURCES

2.1 Biodiversity and Plant Genetic Resources

For millennia, living species have been evolving, dispersing, and scattering beyond their native areas. Confronted with various habitats, they gradually adapted to their new environment and climate under constraints, natural and manmade, that created very broad genetic diversity within each species. This forms what we call today PGR. The PGRs of particular importance to humans are those that comprise food and agriculture, including the diversity of genetic material contained in traditional seed varieties and modern cultivars, as well as wild plant species that can be used as food, feed for animals, fiber, shelter, energy, etc. Until now, this broad diversity was considered a free and available commodity available for common use.

In 1995 it was estimated that among the 250,000 species of higher plants identified, about 30,000 are edible and about 7,000 plant species have been used as food in agriculture. Thus, several thousand species with extensive diversity are considered to contribute to food (Wilson 1992). Cultivated PGRs are classified into three broad categories, namely “modern varieties,” “farmers’ varieties,” and “landraces and wild relatives’ species.” [1]

- Modern Varieties (sometimes called high-yielding varieties) are the products of plant breeding in the formal system. They typically have a high degree of genetic uniformity.
- Farmers’ varieties, otherwise known as traditional varieties, are the product of breeding or selection carried out by farmers, either deliberately or not, continuously over many generations. Farmers’ varieties tend not to be genetically uniform[2] and contain high levels of genetic diversity (Tomooka 1991; Ceccarelli et al. 1992; Alika, Aken’Ova, and Fatoukan 1993).
- Landraces and wild relatives, however, can be recognized morphologically. Farmers have names for them and different landraces differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use as well as in hue, taste, nutrition, preservability, medicinal quality, pest, drought and flood resistance (Harlan 1975).

2.2 The Value of Genetic Resources and Genetic Diversity to Smallholder Farmers

Farmers in fertile and/or irrigated areas who can afford to invest in appropriate improved crop varieties and external inputs are usually rewarded with increased yield and income. The majority of farmers in developing countries however, particularly poor farmers in rain-fed ecosystems, cannot afford expensive external inputs such as fertilizers, pesticides or seeds adapted and improved for profitability. So it is thanks to the genetic diversity of traditional plants—both at intra and interspecific levels—that are well adapted to locally poor conditions that such farmers continue to survive.

The majority of poor farmers live in arid zones with low soil fertility and unpredictable conditions, such as poor or erratic rainfall, very long or short growing seasons, and lack of external inputs. In such environments, it is the local varieties and landraces which provide smallholder farmers with a more reliable crop yield.

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[1] Landrace refers to varieties selected and improved by farmers. Landraces are adapted to specific ecosystem environments of farmers’ farm.

[2] This depends to some extent on whether the species is open- or self-pollinating.

2.3 Contribution of Plant Genetic Resource Diversity to Modern Varieties

PGR diversity represents a vast genetic "library" from which we can obtain many useful genes. Each variety of plants possesses value to humankind that remains undiscovered, so PGR diversity represents a true “resource” which humankind can continue to turn to for agriculture, food, medicine, industry and other future uses.

Specific genes or gene combinations provide valuable benefits including agronomic qualities such as resistance to pests, diseases, and drought; adaptations to abiotic stresses such as salinity tolerance, plant stature, and other factors affecting productivity; quality factors such as higher oil or protein content; as well as culinary and other factors of cultural importance. These traits are both important to farmers and of major global significance as they are introduced into many modern varieties.

For example, wild relatives together with weedy species which have evolved over a long period of time and have coevolved with pests and diseases contributed greatly to plant improvement (Harlan 1981). Plant breeders commonly use wild species as gene donors to improve pest and disease resistance among cultivated species.

2.4 Rapid Decline of Plant Genetic Resource Diversity

The loss of genetic diversity (also called “genetic erosion”) includes the loss of individual genes and the loss of particular combinations of genes. This causes reduced biological fitness and increased chances of extinction.

The 2008 International Union for Conservation of Nature (IUCN) Red List states that of 12,055 species of plants assessed, 8,457 (or 70%) are currently threatened with extinction (IUCN 2009).

Since the 1960s, a significant decline of varieties and plant species cultivated in agriculture has led to the rapid loss of PGR that hold lesser economic interest or solely local interest. The ongoing erosion of PGR has decreased the intra-specific genetic diversity of many crops. According to recent Food and Agriculture Organization (FAO) (1997) estimates, 8.75% of the genetic diversity of crop plants was lost in the last century. A survey by the ETC group (Erosion Technology and Conservation group) found that approximately 97% of PGR have been lost in the last 80 years.

2.5 Causes of Plant Genetic Resource Decline

According to the FAO, the causes of genetic erosion in crops are tabulated by country below:

Cause	Number of countries
Land clearing	61
Population pressure	46
Environmental degradation	33
Legislation/policy	22
Pests/weeds/diseases	9
Civil strife	6
Overexploitation of species	52
Reduced fallow	6
Overgrazing	32
Replacement of local varieties	81
Changing agricultural systems	18

Source: Country report in *The State Of The World’s Plant Genetic Resources For Food And Agriculture*, FAO, Rome 1997.

Concerning food crops, genetic vulnerability and genetic erosion are mainly caused by: (i) excessive genetic uniformity of a few high yielding modern varieties, (ii) collateral damages caused by conventional agriculture, (iii) contamination by genetically engineered (GE) crops, and (iv) global climate change.

(i) Genetic erosion resulting from excessive genetic uniformity in crops

Perhaps the most important factor affecting PGR decline is the displacement of local cultivars by improved varieties, and the displacement of local crops altogether by crops that do better on the market. Other factors include habitat destruction affecting the wild gene pool, changing cropping patterns, and the effects of long periods of droughts. As old varieties in farmers' fields are replaced by newer ones, genetic erosion frequently occurs because the genes and particular combinations of genes (e.g., of gene complexes) found in the diverse farmers' varieties are not contained in the modern high-yielding varieties.

It is known that many of today's widely planted modern varieties of food crops are impressively uniform genetically and are therefore vulnerable. The extent of uniformity is not always apparent because pedigrees are not always available, even for the most popular cultivars. In addition, data on areas sown with different cultivars of the same crop are not usually available. Uniformity per se is not dangerous, for some crop cultivars are remarkably stable.[3] However, the dangers of planting large areas with a genetically uniform crop variety must be recognized, as these varieties could suddenly become uniformly susceptible to new pathogen races and be wiped out. The most famous example of this is the potato famine of 1845–1848, when a pandemic of late blight (*Phytophthera infestans*) wiped out the potato crop in Europe and North America.

(ii) Collateral damages caused by conventional agriculture

The absence of genetic variation in hybrid varieties of modern agriculture has led to the spread at an alarming rate of plant pests and diseases. This has caused the gradual and widespread extinction of traditional varieties and landraces grown nearby and those not receiving pesticides, like hybrids.

The excitement surrounding high-yielding hybrid varieties so captivated scientists and farmers that few foresaw the resulting displacement of indigenous genetic resources or their eventual extinction. The role of farmer as protector of crucial gene species such as sorghum, millet, buckwheat and beans was forgotten. Every effort was made to replace local varieties with high yielding ones, viewing the former as primitive.

(iii) Genetic vulnerability caused by the cross-contamination by GE crops

A new phenomenon may threaten the genetic diversity of the seed supply: the contamination of landraces and traditional seeds by DNA sequences derived from GE crop varieties.

In the US and other Western countries, there are a handful of examples of genes from genetically modified (GM) varieties found at low levels in non-GM varieties of some major crops grown nearby, raising the possibility of widespread contamination of food crops. Among the potential contaminants are genes from crops engineered to produce drugs, plastics, and vaccines.

In fact, contamination events are inevitable. Gene flow is a regular and natural occurrence among plants in any ecosystem; if a gene is released, it will escape to other varieties of the same crop or to its wild relatives. It is clear that zero contamination is impossible at present and that there is no way to ensure that food crops are not contaminated, for example by errant pollen that possibly contains new drug genes or herbicide-resistant genes. According to the degree of gene flow, the serious possibility of healthy gene pool erosion exists if

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[3] By broadening the diversity of resistance genes and "pyramiding" multiple genes from different sources, breeders can strengthen resistance even in genetically uniform varieties.

genes from pharmaceutical and industrial crops contaminate the seeds of food crops at a significant level.

There are broad implications to the recognition that plant genetic diversity is shrinking rapidly and that the seed supply is open to contamination by low levels of a wide variety of GE sequences.

First, seeds reproduce and carry genes into future generations. Every season of seed production offers new opportunities for the crossing and exchange of genes or the introduction of new genes. In the case of GE, transgenic sequences that enter the seed supply of traditional crop varieties will be perpetuated and will accumulate over time in plants where they are not expected and could be difficult to control.

Second, seeds are the wellspring of our food system, the base upon which we improve crops and the source to which we return when crops fail. Non-contaminated seeds will be our only recourse if prevailing beliefs about the safety of GE seeds proves wrong.

Unless some part of our seed supply is preserved with a broad genetic base and free of GE sequences, our ability to change course if GE goes awry will be severely hampered. Prompt action is needed to protect traditional and landraces seed production from such sources of contamination.

(iv) The threat of global climate change

Climate change is already forcing plant species to adapt either by shifting habitats, changing life cycles or developing new physical traits. The species that are unable to adapt are facing extinction. Climate change threatens food crops as well as the few remaining landraces and wild relatives of key crops, a valuable source of genetic diversity. As a result, human dependence on wild relatives will intensify as the climate becomes harsher.

Farmers—especially smallholder farmers—are among the first to suffer from climate change. Changing weather patterns increase the frequency of droughts, floods and storms, which destroys farmlands, stock and rural dwellings. Plant species are disappearing at an unprecedented pace already. Farmers have to adjust to these changes by adapting their seeds and usual production systems to an unpredictable situation. Moreover, droughts and floods are leading to harvest failures, increasing the number of people that go hungry in developing countries.

According to the FAO, global warming is likely to lead to a serious decline in agriculture production in tropical areas (up to 30% to 50% in Senegal and in India) and to the acceleration of farmland desertification. On the other hand, huge areas in Russia and Canada will turn into arable land for the first time in human history, yet it is still unknown how these regions will be able to grow crops (FAO 1997).

Given the importance of the climate-biodiversity link, conservation through sustainable use of the traditional and landraces varieties that are especially resilient to climate change can strengthen and improve the ability of ecosystems to deal with increasing climatic pressures. At the same time, the increased flood and drought under climate change is contributing to higher level of species loss and therefore conservation efforts are ever more important.

2.6 Consequences of Gene Pool Erosion

The erosion of PGR diversity poses a severe threat to the world's food security in the long term as the loss of landraces and traditional varieties will affect negatively the ability of agriculture to adjust itself to climate change and its effects.

The extinction of plants in a species could potentially mean an undiscovered cure for cancer, an overlooked new antibiotic drug (like the antibiotic discovered in the soils of the threatened New Jersey Pine Barrens Natural Area) or a forgotten disease-resistant plant species (like the perennial disease-resistant corn found in Mexico) and therefore is a serious problem.

If lost, the particular combination of genes in a well-adapted landrace may be difficult or impossible to rebuild.

3. PLANT GENETIC RESOURCE PRESERVATION AND ORGANIC AGRICULTURE

Today the vast majority of countries have recognized the need for appropriate conservation strategies to protect cultivated and traditional PGR, wild relatives, ecosystems, and the traditional knowledge associated with them. The threat to biological diversity was among the key topics discussed at the UN World Summit for Sustainable Development in 2002, with participants united in their hope to a Global Conservation Trust to help maintain plant collections. The conservation of biological diversity has become a global concern.

In situ conservation is considered the most desirable conservation strategy but sometimes it cannot be done. The destruction of rare or endangered species' habitats also requires *ex situ* conservation. Some believe both types of conservation are required to ensure sound preservation.

Both methods of preservation should ensure the perpetuity and guarantee the quality of a large gene pool, not just of “useful” genes but also including highly diversified resources that are capable of providing for future needs we know absolutely nothing about.

3.1 *Ex situ* Preservation Including Seed Banks

The response of the international community to the loss of biodiversity has been the establishment of seed banks. According to the FAO, in 2002 there were about 1,300 banks containing around six million (plant accession) acquisitions from around the world. However, this amount represents a small fraction of seed biodiversity and many important regions have been overlooked on collecting expeditions (FAO 2009).

An example of a global *ex situ* conservation effort is the so-called “Doomsday Vault” opened on 26 February 2008 and carved into the permafrost of a mountain in Norway’s remote Svalbard archipelago near the North Pole. It was planned with the climate change factor taken into consideration and will be frozen 200 years from now. This top-security repository was designed to protect and preserve samples of valuable seeds and is aimed at providing humankind with food in case of a global catastrophe. The vault can store more than four million batches of seeds from all known varieties of the planet's crops. The hope is that the vault will make it possible to re-establish crops that are endangered or obliterated by major disasters. The seeds will be maintained at a temperature of minus 18°C. Each box will contain about 400 samples in envelopes made of polyethylene and each sample will contain around 500 seeds.

There are serious drawbacks to this approach for conserving biodiversity. Varieties stored in seed banks are small-sized populations adapted to the conditions of cold storage and could become extinct if they are not regularly sown and replanted outside to generate viable seeds. For example, the most important wheat collection in Asia (held at the University of Kyoto) grows only five plants per variety for regeneration. Stored varieties become very uniform and adapted to the artificial environment of cold storage. Small samples of seeds collected and stored in such way could actually result in the continual depletion of variability and adaptability. They are more prone to extinction than large populations as they are more sensitive to genetic drift due to the random variation in their gene pool resulting from their limited genetic base. Each plant has many unique genes (resistant to diseases, drought, flood or high or low temperatures) which are lost when the plant dies without getting the chance to breed naturally and produce offspring.

So, one wonders if 500 seeds per sample will be enough to avoid genetic drift. Could those seeds adapt to their new environment once removed out of the seed bank 200 years from now?

There is also a serious lack of contextual knowledge about the material stored in seed banks. Without information about the farming systems in which these crops were grown and the planting rotations they formed, these varieties cannot be of use to future farmers.

So seed banks' effectiveness could be limited due to genetic drift of small-sized populations and limited adaptability to future environments as well as the lack of capacity by national agricultural research centers and universities to reproduce or multiply seeds regularly on a sufficient scale to preserve variability and adaptability.

3.2 *In Situ* Preservation

In contrast to *ex situ* conservation, *in situ* conservation permits populations of plant species to be maintained in their natural or agricultural habitat, allowing the evolutionary processes that shaped genetic diversity and the adaptability of plant populations to continue to operate (Frankel and Soule 1991).

In situ conservation includes (i) specific conservation measures for crop wild relatives and wild food plants, particularly in protected areas, and (ii) conservation and sustainable utilization of landraces or traditional crop varieties on-farm and in home gardens. Details about these two approaches are discussed below.

3.2.1 Conservation of Plant Genetic Resources in Protected Areas

Worldwide, protected areas number 9,800 and cover approximately 926 million hectares of the earth's surface (International Union for Conservation of Nature 1999).

Among them, Turkey has initiated a project to conserve, *in situ*, crop-related wild relatives of cereals, medicinal plants and forest trees with support from the Global Environment Facility. The project will also serve to develop and implement a national strategy for *in situ* conservation, and test and develop new approaches in wild crop species biodiversity conservation.

Israel has conducted pioneering research on *in situ* conservation strategies for wild emmer wheat. Based on the concept of "dynamic gene preservation" of interacting populations in the wild, the plants continue to interbreed, forming new genetic combinations, but the genes themselves are, for the most part, preserved as long as the overall system stays in equilibrium.

However, these examples are rare despite the importance of wild and semi-wild food plants to the livelihood of many poor communities. Moreover, many problems exist in "protected areas." including inadequate knowledge of the distribution of wild relatives, a lack of clear research priorities and methodologies and insufficient management tools for ensuring minimum viable population sizes of target species.

As a result, PGR conservation in protected areas is not really safe unless special measures are taken to ensure the active participation and involvement of local communities in the selection, establishment and management of such areas. Most importantly, since the approach requires large amounts of public funding, continued political support to necessary to sustain long-term conservation.

3.2.2 On-Farm Conservation

Conservation by farmers of landraces and traditional crop varieties differs in important respects from *in situ* conservation of wild material in protected areas. A landrace has generally been selected to suit the environment in which it is cultivated and to satisfy the particular needs of its growers, such as flavor and cooking qualities. Through the particular case of on-farm conservation, landraces continue to evolve, influenced by natural selection as well as by the farmer-induced selection processes, thus providing opportunities for continuous crop adaptation and improvement.

The biological features of different types of crops influenced smallholder farmers' ability to experiment with local plant genetic resources and to maintain landraces. While it is relatively easy for them to maintain a landrace population of a self-pollinated crop such as rice, it is more demanding to maintain a landrace population of a cross-pollinating crop such as maize. However, although there may often be continued gene introgression with wild relatives in the vicinity, landraces are safeguarded and constantly developing through farmer selection. On-farm conservation, which is a dynamic form of PGR management, offers many opportunities to combine genetic diversity conservation with agricultural development.

Although there are few instances of formal on-farm conservation, smallholder farmers around the world continue to cultivate local varieties whose taste, cooking quality, and storage characteristics of traditional varieties are preferred over the improved varieties. According to the Plant Genetic Resources Center of Ethiopia, Ethiopia is probably the country with the most advanced program of on-farm conservation of landraces to maintain crop diversity and the production of food for local consumption and local markets. In most parts of the world, many of the traditional diversity-based farming systems are disappearing. Landraces and local varieties persist but many are in isolated and marginal areas.

Home gardens also constitute a valuable part of a PGR *in situ* conservation system, but their importance in genetic resource conservation is still not widely recognized and few inventories have been carried out.

3.2.2.1 Capacity of Smallholder Farmers and Communities to Manage Plant Genetic Resource Preservation

The main factors that strongly favor the involvement of smallholder farmers in PGR preservation are: (i) the level of exposure to external influence such as agricultural modernization or other socioeconomic changes, and (ii) the indigenous knowledge of landraces and their technical skills.

(i) Exposure to external influence

Local capacity for PGR preservation can vary greatly between different geographical locations. Communities located in centers of plant genetic diversity that have managed local PGR for centuries more or less uninfluenced by outside developments, have a high capacity to manage PGR.

(ii) Indigenous knowledge

Smallholder farmers are usually located in remote areas, far from genetic pollution and their knowledge on traditional varieties and landraces is extensive and could thus contribute greatly to their safeguard. Many examples of valuable information relating to plant genetic resources exists within local and indigenous knowledge systems in many parts of the world (Warren, Slikkerveer, and Titilola 1989). This knowledge ranges from traditional uses of plants to strategies for the management and conservation of landraces, differences among landraces in their resistance to pests and knowledge of pests and pest control methods, traditional selection and breeding methods, environmental monitoring and early warning systems for ecological change (Altieri 1993; Box 1998).

Local people have knowledge not only of the distribution of particular wild plants but may also have 'sanctuaries' of high diversity which are often actively protected by the communities as sacred groves that function as both spiritual centers and biodiversity and food security insurance for surrounding communities (Raishankar et al. 1994; Chambers 1999).

An understanding of local seed production and exchange systems can help to characterize the origin, genetic base and degree of adaptation of germplasm (Cromwell 1990). Folk classifications often correspond to scientific classifications, at both the interspecific and intra-specific levels (Berlin 1992; Berlin, Breedlove, and Raven 1974; Alcorn 1984; Quiros et al. 1990). There are also numerous cases of the names of landraces reflecting not just appearance but intrinsic qualities such as cooking characteristics (Boster 1984).

Evidence also shows that farmers can evaluate varieties for desirable characteristics. For instance, farmers in Kordofan (Sudan) associate sorghum varieties with the type of soil in which they grow best (Oughenor and Nazhat 1985). Farmers in Lao PDR know which of the local varieties are more suitable for a dry year with a short growing season. There is evidence that farmers are aware of differences among landraces in their resistance to pests, and that they have considerable knowledge of the biology of pests and pest control methods (Altieri 1993).

The keepers of much of this knowledge are often the elders in rural communities. However, due to increasingly rapid cultural change and mass rural to urban migration in the latter half of this century, there is a danger that such knowledge and useful practices may not be passed on to younger generations and could be lost forever.

The capacity to manage PGR also varies considerably within communities and depends on the ethnic group, social status, gender relations and age of the farmer. Different social groups of farmers within a community may use different varieties of the same crop, adapted to optimize performance under each individual farmer’s respective resource constraints.

The traditional knowledge and practical skills which accompany farmer selection are fundamental to on-farm management to improve and preserve PGR. The recognition, documentation and use of indigenous knowledge are very important to the safeguarding and utilization of PGR for food and agriculture.

3.3 Partnerships Between Farmers to Preserve Plant Genetic Resources and the Public Sector

PGR diversity is generally agreed upon as global public good. Therefore, policies and regulations which promote sustainable on-farm conservation of crops must be considered at international and national levels.

3.3.1 At the International Level

The Treaty on Plant Genetic Resources for Food and Agriculture entered into force in June 2004 recognizes the rights of farmers involved in the preservation of PGR diversity. The Treaty aims at:

- recognizing the enormous contribution of farmers to the diversity of crops that feed the world;
- establishing a global system to provide farmers, plant breeders and scientists with access to plant genetic materials; and
- ensuring that recipients share benefits they derive from the use of these genetic materials with the countries where they have been originated.

Article 9.2 of the Treaty reads:

9.2 The Contracting Parties agree that the responsibility for realizing Farmers’ Rights, as they relate to plant genetic resources for food and agriculture, rests with national governments. In accordance with their needs and priorities, each Contracting Party should, as appropriate, and subject to its national legislation, take measures to protect and promote Farmers’ Rights including:

a. Protection of traditional knowledge relevant to plant genetic resources for food and agriculture;

b. The right to equitably participate in sharing benefits arising from the utilization of plant genetic resources for food and agriculture; and

c. The right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of plant genetic resources for food and agriculture.(FAO 2009)

The Treaty leaves government with the responsibility of measures to bolster PGR farmers. However the Treaty makes provision for financial resources provided by developed countries to support priority activities plans and programs for conservation and sustainable use of PGR.

3.3.2 At the National Level

Government should support farmers involved in PGR preservation through cooperation with research institutes and by sponsoring relevant legislation and regulation.

(i) Collaboration with Research Institutes

Inventories of ecosystems must be carried out in collaboration with farmers to identify sites where specific species can be conserved *in situ*. Comprehensive inventories of existing diversity that is being conserved by smallholder farmers can assess the total diversity of particular species and thus permit the establishment of priorities for conservation. They also help to identify and avoid duplication and redundancy of traditional varieties and landraces and instead promote the preservation of abundant biodiversity.

Research institutes can support farmers especially in preserving and maintaining landraces and traditional varieties. Farmers actively select varieties on the basis of phenotypic characteristics (easy to observe visually), rather than the associated genotype characteristics used in scientific plant breeding. Cooperation may be needed to improve the farmers' ability to select for increased yield and other characteristics that they desire. One example is the work of the Biodiversity Institute in Ethiopia which screens local landraces of sorghum for drought tolerance and returns the most drought-tolerant varieties to farmers.

Further work in collaboration with farmers is needed with regard to the development of protocols for conservation of wild relatives with a special focus on on-farm conservation and studies of farmer management of PGR (meeting the minimal quantity required to maintain a large genetic base of PGR). Farmers can assist research centers in the development of breeding objectives, in germplasm characterization, conservation and evaluation and in testing the capacity of varieties to germinate and produce seeds.

(ii) Legislation / regulation

There is a need for *in situ* conservation programs to be integrated with national development plans and policies. There is also a need to review and adapt agricultural development policies and regulatory frameworks for variety release and seed certification to understand their impact on PGR.

Governments should introduce specific legislative, regulatory, and financial measures for encouraging the local production, storage, and marketing of landraces and varieties that are naturally adapted to the local and regional conditions.

4. MARKET-BASED STRATEGY

4.1 Role of Organic Agriculture in Protecting Plant Genetic Resources while Providing Improved Income

As discussed above, among the different approaches to protect and maintain the remaining PGR, *in situ* on-farm conservation by smallholder farmers can be more effective and less costly compared to the option of preserving them in protective areas. To do so, beyond having international agreements and a regulatory framework, incentive systems must be put into place for researchers and farmers to collaborate with each other. While systems to provide incentives for researchers are largely available and is largely subject to the discretion of research budgets, the challenge is to create incentive systems for poor farmers who are the protectors of the remaining PGR to collaborate with researchers to continue to maintain the PGR in a more effective and systematic manner.

Under current circumstances, the remaining PGR are being protected *in situ* by smallholder farmers in less privileged agriculture areas. Because they are generally poor, the challenge is not only to provide incentives for them to continue to play a role of protector of the remaining PGR but also to provide them with sufficient income to pull themselves out of poverty. To date, the conventional development strategy is to introduce poor farmers to high-yielding commercial varieties with a goal of improving their productivity and therefore income. However, this conventional strategy of development has had mixed results on poverty reduction but has definitely led a to rapid decline of PGR. An alternative strategy where the value of the PGR can take into consideration must be urgently identified.

Among the various commercial farming systems practiced by smallholder farmers, organic agriculture,[4] in particular certified organic agriculture, stands out as one of the most promising farming systems. Organic agricultural systems are technologically appropriate while allowing market instruments to provide incentives and rewards for PGR conservation by farmers.

Unlike input-intensive farming systems, organic farms must rely on biological management methods to obtain optimal product quality, yields, and production costs. Synthetic inputs such as chemical fertilizers and pesticides are strictly excluded from organic farming systems. In addition, reliance on organic fertilizers and pesticides is not economically sustainable in the long term and such inputs are used primarily during the conversion to organic agriculture.

Since organic farmers tend to produce to serve niche markets where traditional varieties are often promoted as being more nutritious, organic farmers are likely to cultivate older, native varieties that have greater resistance to disease and pests and are better adapted to climatic stresses in the local ecosystems. These locally adapted, open-pollinated varieties are more appropriate for organic agriculture than hybrid varieties which require inputs, and are an important genetic resource for poor farmers in marginal areas. By utilizing traditional varieties, organic agriculture has significant potential to restore and preserve PGR (Sciallaba, Grandi, and Henatsch 2002).

Overall, organic farming has the technical capacity to maintain a high level of PGR. Organic farms grow a wide variety of crops, in contrast to the monocropping typically found on

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[4] Organic agriculture is a holistic production system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. Organic systems rely on ecosystem management practices rather than external agricultural inputs, and exclude synthetic inputs such as synthetic fertilizers, pesticides and genetically modified seeds. Certified organic agriculture refers to products which have been produced, stored, processed and handled in accordance with organic standards and certified as “organic” by a certification body. Non-certified organic agriculture refers to products which meet the requirements of organic practice but are not certified. These products are typically produced for household consumption or sold in local markets (International Federation for Organic Agriculture Movement).

conventional farms. In many cases encountered during a series of field visits in Thailand, organic farmers responded to the call for increased biodiversity under organic certification and grew under-utilized species as rotation crops or intercropping species. They also grew indigenous varieties according to their culinary preference. These practices lead to increased soil fertility, reduced costs of pest and disease management and have a positive impact on crop biodiversity (Setboonsarng 2006). Thus organic agriculture not only reduces erosion of agro-diversity but also creates a healthier gene pool—the basis for future adaptation. Moreover, as certified organic farms are located far from areas where GE plants are grown, the risk of germplasm cross-contamination is minimized.

The market-based incentives are also in place as the global organic trade has increased rapidly, growing from a from US$11 billion in 1997 to over US$50 billion in 2007 and predicted to reach 61 billion in 2010 (International Federation for Organic Agriculture Movement 2008). The exponential growth rate of 18–23% annually in recent years is caused by increased awareness that organic products are better for health and the environment. The growing demand for organic products has increased the economic value of a number of traditional or underutilized crops, and has provided livelihoods to poor communities in marginal areas of developing countries. Evidence shows that private sector firms are investing in remote areas where chemical use has been limited and a transition period to obtain certified organic status is not required. Poor farmers with traditional knowledge of managing ecosystems without using chemicals have a competitive advantage in growing organic crops. With the organic farmers receiving premium price for their products, economic incentives are in place for them to adopt sustainable practices and maintain a high level of biodiversity on the farm as required by the certification system (Setboonsarng 2008).

The promotion of organic agriculture to maintain PGR can be done in two ways. One way is to promote the commercialization of traditional varieties by finding markets for crops. Increasing consumer demand for specialty products, motivated by health concerns and culinary tastes, has led to the restoration of varieties at risk of genetic erosion. The development of a market for specialty products has been successful in certain cases, such as the promotion of the nutritional value of gluten-free quinoa[5] from Peru or the marketing of traditional potatoes in Peru by an NGO (Sciallaba, Grandi, and Henatsch 2002).

Since the majority of poor farmers have a taste preference toward local varieties, another way to use organic agriculture to maintain PGR is to introduce commercial organic production of new crops demanded by the market in part of the farmers' farm, while encouraging the farmers to maintain production of traditional crops for consumption on another part of the farm. In that way, farmers can earn income from commercial crops while preserving the traditional crops *in situ*.

Organic farmers could possibly be more willing to work closely with researchers to systematically document PGR than conventional. This is because organic farmers need to find new ways to manage their farms using modern organic practices to achieve higher levels of production while conserving the environment. If designed appropriately, the price premium and the added income from organic produce could become market-based incentives to involve poor farmers worldwide to participate in the preservation of PGR.

5. CONCLUSION

Biologists and environmentalists have sounded convincingly the alarm regarding the urgency of conserving biodiversity and in particular the PGR. A better understanding of the adaptation and development of crop species to changes in the environment are fundamental to safeguarding PGR diversity effectively. At the global level, there is a consensus about the

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[5] Quinoa is a nutritious cereal grown on the hardiest land of the Andes in South America.

fast genetic erosion of PGR diversity and the urgent need for the preservation of a large genetic base of cultivated crops in order to ensure food security for future generations.

A global architecture and mechanisms have set up to these ends, including the Treaty on Plant Genetic Resources for Food and Agriculture and seed banks. At the national level a number of national agricultural research systems are already working on ways to preserve and develop PGR.

At the grassroots level, smallholder farmers and rural communities in developing countries who have not adopted the conventional agriculture practices of the Green Revolution have instead been maintaining and continuously adapting their indigenous crop resources (including traditional varieties and landraces) and preferred varieties on-farm.

It is impossible to overstate or truly estimate the importance of the crop materials that smallholder farmers are using and conserving. In the first place, this genetic diversity is crucial for the farmers themselves. Their crop varieties are probably the only ones that can take the farmers and their families through the periods of drought. But they also provide for year-round harvest security in the harsh conditions under which farmers in most developing countries are trying to get some food from their land. Plant breeders worldwide look for commercial varieties with characteristics which have potential economic value. For instance, when screening gene bank materials, they repeatedly find seed samples of Ethiopian origin to be particularly rich. In the context of globalization of agricultural trade, genetic diversity also helps out farmers and companies in other parts of the world.

While normally the formal sector tends to pay little attention to this innovative capacity of smallholder farmers or local communities to save plant genetic diversity, an alternative strategy involving smallholder farmers in several stages of the seed-saving and breeding process is a valuable option for preserving genetic diversity. There is an urgent need to maintain landraces growing under field conditions in order to preserve a large genetic base, and for use in crop improvement programs. Landraces adapt gradually to the changing environment and climate, and this is probably best achieved through on-farm conservation programs. However, the direct benefits for peasant farmers are likely to be quite limited, in particular for food crops and especially for farmers in semi-arid areas.

As public funds are limited, in order to encourage farmers to participate in long term sustainable safeguarding of genetic diversity through their traditional landrace varieties, incentives must be created. Certified organic agriculture could be one of the most promising: it is technologically appropriate—smallholder farmers favor local varieties not only for their greater resistance to disease but for the taste and cooking quality—and financially rewarding, due to the rapidly increasing global organic trade and the growing demand for health and specialty foods.

Through the development of market incentives for cultivating traditional and underutilized varieties, and the promotion of sustainable practices, certified organic agriculture is a potentially effective means of preserving plant genetic resources *in situ*. The role of the public sector in this process will be to develop markets for organic and traditional products, encourage pro-poor private investment in organic agriculture, and establish research centers to collaborate with farmers to identify and document indigenous varieties.

By assisting farmers in using techniques for certified organic food, we involve farmers not only in conserving germplasm but also in restoring and enhancing the performance of traditional varieties, and by developing and maintaining elite landraces. Farmlands act not only as sources of food, but also as village gene banks for a wider range of landraces, which can be used as a depository for a wide range of useful genetic characteristics.

In an era when climate change, poverty, food safety and other environmental concerns are high on the international agenda, promoting trade of pro-poor and pro-environment goods such as organic products should be promoted in all economic development efforts.

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