PANAP RICE SHEETS

SAVING THE RICE SEED

1.0 THE RICE SEED

The agricultural revolution was the first revolution in the history of human civilization. It fundamentally changed the way humans lived, from being nomadic hunter-gatherers to sedentary cultivators.

The domestication of plants and animals made possible the production of more food than ever before, leading to larger populations and more complex societies. Seed is the embodiment of that revolution. One legacy of about 10,000 years of farmers collecting, propagating, breeding, selecting and caring for seeds is the existence of more than a hundred thousand varieties of rice alone.

These rice varieties are a precious treasure trove of agricultural biodiversity. Among them are varieties ideally suited to an enormously broad range of environmental conditions and human needs. Today, however, this incredible diversity is at risk. And the principal threat to it is the reckless expansion of modern industrial agriculture around the world. Industrial agriculture is eroding and displacing both traditional rice varieties and farmers' knowledge and skills necessary to cultivate and preserve such varieties.

To conserve the world's store of rice agro-biodiversity, many Northern governments, multilateral institutions and foundations favor a highly technical and expensive approach: the use of cold-storage gene banks. While gene banks have some merits, this paper will argue that the optimal strategy for saving the world's rice seeds is to put conservation back into the hands of the true experts: the rice farmers themselves.

1.1 Rice Varieties in Asia

Rice's origins are in Asia, where the world's greatest number of rice varieties are found. The International Rice Genebank (IRG) at the International Rice Research Institute (IRRI) maintains a collection of more than 107,000 accessions[1], mostly landrace or breeding materials of *O. sativa, O. glaberrima*, and wild species. The rice accessions from Asia and the Pacific that are stored at the IRG in IRRI are presented in Table 1.

Table 1. Rice accessions from Asia and the Pacific stored at the IRG of IRRI

Country	No. of Accessions	Country	No. of Accessions
India	15,272	Nepal	1,487
Indonesia	8,365	Laos	1,309
China	7,377	Cambodia	1,150
Thailand	5,583	Japan	1,127
Bangladesh	5,499	Pakistan	1,075
Philippines	4,419	Korea, Rep. of	1,033
Malaysia	2,646	Bhutan	231
Sri Lanka	2,104	Brunei	139
Myanmar	1,795	Papua New Guinea	46
Taiwan	1,791	Fiji	26
Vietnam	1,611	Korea, PDR	7

Source: GRAIN compilation, 1994

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[1] An accession is a collection of seeds acquired at one time from a single source. The collection is given a unique accession number which is stored in a database with information on the characteristics of the accession.

Asia accounts for 92% of global rice production and consumes more than 90% of this production. Eighty percent of the rural population depends directly on rice crops, especially the region's small farmers. Most of the rice harvest is for domestic consumption and only 6% is traded in the international market. Rice also has deep social and cultural significance: "to eat" in Asia is almost always synonymous with "to eat rice".

1.2 Formal and Informal Seed Systems

For farmers, "seed" refers to any plant part which can reproduce the same kind of crop. Farmers traditionally selected and saved seeds from each harvest to replant the next season, resulting in the continuous improvement of varieties. When planted in different agro-ecological conditions, crops naturally evolve, diversifying the number of varieties. Local varieties (also called farmers' varieties, traditional varieties or landraces) are varieties bred and selected by farmers.

These tend to have high levels of genetic diversity. In contrast, modern or high-yielding varieties (HYVs) are products of formal, institutional and scientific plant breeding and typically have a high degree of genetic uniformity. These two methods of seed production lead to seed systems with markedly different characteristics.

A seed system, either formal or informal, fulfills a series of functions that are basic prerequisites for expecting the best possible productivity from a crop in a specific situation. Healthy, viable seed of the preferred variety needs to be available at the right time, under suitable conditions, so that the best yield expectations by farmers can be realized. As the primary agricultural input, seeds mainly determine a farmer's future harvest (Musa, 1999).

In developing countries, an estimated 90% of all seed used for food production still comes from farmer-saved seeds (Almekinders *et al.*, 1994). Even in countries with advanced agricultural production systems, informal seed systems still contribute to over 30 percent of all seed in self-pollinated food crops (Ghijsen, 1996). These seed systems have always been viable and resilient to disasters because they are well adapted to the local environment and evolve in response to local conditions as farmers repeat the cycles of crop production.

Farmer seed systems are complex and include much more than just seeds themselves. Seed selection, development, production, storage, distribution and exchange are all components of farmer seed systems. They are heterogeneous in space and flexible in time, ensuring their continuing viablility (Musa and Rusike, 1997; Rohrbach, 1997). They allow for the effects of introgression (accidental cross-pollination) and selection pressures exerted by natural factors and humans. In short, informal seed systems address the needs of farmers over a range of economic, social, cultural and agro-ecological conditions.

In the formal seed system, on the other hand, seed production is separate from crop production. Professional seed developers, rather than farmers, produce the seed. For this reason, formal seed development often ignores the social and ecological components of agricultural production and the ways in which agriculture relates to wider livelihood strategies. The high degree of genetic uniformity of seeds produced in the formal system make crops more vulnerable to disease, pests and environmental changes.

A reliable, sufficient, and accessible seed supply system that meets the planting needs of farmers is imperative to food security at the household level. This is called farmers' seed security. Any disruption in farmer seed systems can have devastating long-term impacts on household food security. Planting the wrong variety, having poor seed germination rates, or sowing at the wrong time can seriously limit farm productivity. As a result, rural people generally experience food deficit during parts of the year, and poverty exacerbates their difficulty in meeting their food needs.

1.3 Seed Systems as Part of Farmers' Knowledge

Seeds are an integral part not only of agriculture and food production, but of farmers' lives and cultures as well. Farmers adapt many different seeds to their agro-ecological and cultural environment. Seed diversity, expressed as species and varieties, has multiple functions. It sustains and strengthens food security, nutrition, health, and livelihoods.

Rice seeds, and all other agricultural crop seeds, have evolved through a long history of being grown under 'disturbed' (cultivated) environments with persistent selection by farmers themselves. In the process, the yearly reproduction of rice seeds, like other annuals, became dependent on farmers.

Meanwhile, humans also became dependent on seeds, the precious resource which allowed them to grow food and survive. Dependence means hunger when seeds are not viable, when they are not adapted to a particular agro-environment, or when they are damaged by pests or natural disasters. In response, farmers developed and maintained different seeds to suit specific agro-climatic conditions as well as their own goals and preferences. Farmers also developed cropping systems appropriate to their natural and socio-economic conditions.

Farmers know the proper quantity of good seeds of the preferred varieties that must be saved for every planting season. For farmers to have seed security, seeds must be both available and accessible. Seed availability means the amount of seeds harvested during the course of food crop production in a farmer's field should be available in sufficient quantity at the right time and must be sustainable. That is, the seeds can be planted year after year, without deteriorating as in the case of hybrid seeds or high-yield variety (HYV) seeds. For seeds to be accessible, they must be of sufficient quality, affordable, and equitably shared among farmers.

Farmers' knowledge of seed systems is experiential, practical, and tailored to a particular local environment. Their knowledge is not always apparent or easily comprehensible to plant breeders, seed developers and researchers who are trained in technical approaches and who focus largely on one seed characteristic: high potential yield. As a result, other seed qualities that farmers value in seed stock, such as having sufficient straw for mulch, compost or livestock forage; resistance to unique pests in the area; better yield even without chemical fertilizers; and good eating quality, are often ignored in formal seed-development spheres.

1.4 The Rice Seed at Risk

Rice seed diversity has declined seriously as many farmers' varieties and landraces have disappeared. Diverse farmers' varieties are often displaced when commercial varieties are introduced into traditional farming systems.

1.4.1 Displacement by Modern Varieties

The introduction of modern rice varieties through the Green Revolution program is the main reason for loss of rice genetic diversity. Over just two decades (the 1970s and 1980s), rice varieties and landraces developed by farmers under all kinds of agro-ecological conditions were displaced and replaced by "modern" varieties. In Indonesia, some 1,500 traditional rice varieties disappeared between 1975 and 1990.

Indian farmers traditionally cultivated some 30,000 varieties, but now 75% of India's rice comes from just 10 varieties (Ryan, 1992). In Pakistan, 99% of rice fields are planted with only four HYVs (IRRI World Rice Statistics, 2004). Similar trends have been observed throughout the region: at least 85% of the rice fields in Burma, Indonesia, Philippines and Thailand are occupied by HYVs while in Cambodia; a single variety, IR66 from IRRI, accounts for 84% of the country's dry season crop. Cambodia's farmer-selected and improved traditional rice varieties (TRVs) have all vanished because of variety replacement (genetic erosion), except for the samples in the IRRI gene bank (WRI, UNEP and IUCN, 2002).

Thrupp (1998) summarized the roots of biodiversity loss in the developing world as: (1) dominance of industrial agricultural paradigms, policies, and institutions that support homogeneous systems and unsustainable practices; (2) global inequities in the control and distribution of resources; (3) pressure from businesses and market growth that promote uniform monocultures and the related packages of agrochemical technologies; (4) under-evaluation of biodiversity and disrespect of local knowledge tied to such diversity; and (5) policy-induced demographic pressures. Cromwell *et al.* (undated) highlighted that globalization of the food system and marketing, and the extension of the patenting of living organisms have led to the widespread cultivation of fewer varieties for a more uniform, less diverse but more competitive global market. In industrial, globalized agriculture, varieties are selected only for the highest yield; the other multiple criteria farmers use are not considered.

Government programs which recommend and subsidize a few improved and certified rice varieties play a role in displacing farmers' varieties. Often, the mosaic of local rice varieties is replaced with monocrops of one or two HYVs as farmers stop planting their traditional varieties to adopt the new ones.

1.4.2 GE Contamination

Genetically engineered (GE) rice is also a problem because it contaminates traditional rice varieties. Even if rice is self-pollinated, there is still a 10% chance of introgression. Accidental mixing of GMO seeds with traditional varieties can also occur. The contamination of long grain rice in the US by LL601 rice, a herbicide-resistant GE rice in the experimental stage, is strong evidence that contamination can occur largely unnoticed. This GE contamination of two commonly planted rice varieties in the US in 2006 resulted in a shortage of seeds for planting the following year (Jones, 2006).

1.4.3 Marginalization of Farmers

Agricultural biodiversity is actively managed and conserved first and foremost by farmers, and crops would not survive without their local knowledge, cultural wisdom and skills. Modern industrial farming has marginalized small-scale farmers who practice agriculture systems that conserve diverse rice varieties.

Technologies and production methods that marginalize small farmers also marginalize farmers' crop varieties. The effective conservation of rice's genetic diversity therefore requires ensuring the viability of small-scale farming and the use of sustainable, farmer-led agricultural systems.

1.4.4 Terminator Technology

Modern technology is now being used to control seeds, and consequently, agriculture and food. Standardized industrial approaches are now applied to agriculture. But one of the very worst forms of control over seeds that has emerged is through what is called "terminator technology", in which seeds are genetically engineered not to germinate, meaning that they cannot be saved and that farmers will have to buy new seeds every growing season. This highly disturbing development in agriculture constitutes complete technological control over seed by corporations whose only objective is profit. This technology represents a dire threat to not only seed and farmers, but global food security as well.

1.5 International Agreements Affecting Rice Seed Diversity

Genetic resources have always been a public good and common property. Increasingly, however, rice seeds are becoming commodified and privatized through Plant Breeders Rights (PBR), patenting, or outright technological control such as terminator technology. Being one of the remaining frontiers of natural resources, genetic resources have become the subject of many international treaties and agreements. The International Union for the Protection of New Varieties of Plants (UPOV) is one of the oldest multilateral agreements that govern the protection of plant varieties and plant breeders' rights. However, it prohibits farmers from saving and exchanging seeds of protected varieties for commercial purposes. It does allow member states to permit some seed saving as long as farmers pay a royalty. Most of the new restrictions on farmers in Asia are now UPOV-styled plant variety protection laws.

The 1993 Convention on Biological Diversity (CBD) affirmed nations' sovereign rights over their genetic resources. It also covers access to and sharing of benefits from the use of those resources. The World Trade Organization's Trade-Related Aspects of Intellectual Property Rights (TRIPS), under Article 27.3(b), also prescribes the protection of plant varieties through legal measures in the form of patents or an "effective" *sui generis* system or a combination of the two. In practice, this means that IPRs in agriculture favor agribusiness corporations which have the resources to produce the expensive experimental data required for patenting, while farmers are disadvantaged because they cannot afford to provide similar data. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) specifies measures for allowing governments, research institutions and industry users of plant genetic resources to access genetic resources. It also covers mechanisms for sharing benefits from the use of genetic resources.

Most rice genetic resources developed, maintained, and improved by farmers were collected freely and are now kept in gene banks. In 1994, the Food and Agriculture Organization (FAO) and the Consultative Group of International Agricultural Research (CGIAR) entered into an agreement wherein rice accessions acquired before the CBD (i.e. 1993) were 'designated' to the FAO, and that the IRRI would maintain these germplasm as its 'trustee'. Under the agreement, IRRI may not claim ownership or intellectual property rights on the germplasm accessions designated to the FAO. A provision on Material Transfer Agreements (MTAs) is included which specifies that any recipient of the germplasm, including third party recipients, has no right to claim intellectual property rights over the material. The essence of such agreements is to bring back the IRRI rice germplasm collections under inter-governmental authority into the 'public domain' and to protect the designated germplasm from misappropriation or biopiracy. No one will be allowed to have IPRs over the germplasm "in the form received".

However, this is problematic. Even if no intellectual property or other rights can be claimed on the material received, anyone can modify the variety, even through conventional breeding, and then apply for varietal protection or breeder's rights. If one gene is added through genetic engineering, the resulting product can be patented. Compounding the problem, existing legal structures strongly protect plant breeders' rights and patents, but address farmers' rights only minimally, if at all.

2.0 APPROACHES TO SEED CONSERVATION

We need to conserve genetic diversity in order to develop new varieties that can increase yields, adapt to climate change, resist new pests and diseases, and tolerate other threats to crop production. Scientists, governments, NGOs and farmers are increasingly concerned about biodiversity loss and each sector has carried out conservation programs or activities. The formal sector (namely, governments and research institutions) maintains ecological reserves, conducts research, and does conservation through various forms including botanical gardens and herbaria, but most often through highly centralized cold-storage gene banks. The informal sector (farmers, NGOs, etc.) does seed conservation *in situ* through the cycle of production and conservation that is inherent to farming.

In industrial-type farming systems, much crop diversity is now held *ex situ*, in gene banks or breeders' materials. It is only in more traditional farming systems, less touched by government programs of chemical farming, that traditional rice varieties are still grown on-farm.

2.1 Cold Storage Gene Banks

The genetic conservation of rice in the formal sector is almost always synonymous with cold storage, away from the fields where rice is naturally grown. This is also called *ex-situ* conservation. Throughout the world, there are currently about 1,500 *ex-situ* gene banks.

The most diverse and important collection of rice genetic resources in the world is maintained at the International Rice Genebank (IRG) of the International Rice Research Institute (IRRI). It maintains a collection of more than 107,000 accessions, 94% of which is *O. sativa*, 1.5% *O. glaberrima*, and the remaining 4.5% are wild rice species (Koo, *et al.*, 2004b). Some 15,377 rice accessions of African rice are stored at the Africa Rice Center (formerly WARDA) in the Ivory Coast. Ninety-five percent of IRRI's genebank accessions are duplicated at the UN National Seed Storage Laboratory in Fort Collins, Colorado, in the United States (Jackson, 2000). Together with other CGIAR members concentrating on other crops, IRRI's rice collection is being duplicated at the Svalbard facility in Norway.

The IRRI cold storage gene bank has two categories: active collection for medium-term storage and base collection for long-term storage. Its active collection, which is stored at 2°C with a relative humidity of 30-35%, is packed in re-saleable aluminum foil containers weighing 500g each and is claimed to be viable for 20 to 40 years. IRRI also stores some 20g seed duplicates of each accession and 2-5 packets of 10g each for distribution to requesting parties (Koo, *et al.*, 2004a). Its base collection, which is stored at –20 °C, is vacuum-sealed in aluminum cans weighing 60g, each with a duplicate, and is claimed to be viable for 50 to 100 years.

In cold-storage gene banks, seed viability is monitored every 5-10 years to maintain a certain level of viability. *Japonica* rice is more sensitive to cold storage and viability testing is more frequent. Any accession with viability below 90 percent is regenerated by replanting in the field. At IRRI, about 15,000 accessions are tested every year for viability with an additional 8,000 to 20,000 accessions tested from freshly multiplied accessions and incoming new materials.

Regeneration and characterization is done during the dry season to produce high quality seeds. Seed processing and seed health testing are also done to ensure quality. Data and information management is done through the International Rice Genebank Collection Information System (IRGCIS) which is now integrated with CGIAR'S System-Wide Information Network for Genetic Resources database (SINGER, *http://www.cgiar.org/singer*). Previously, IRRI disseminated seed samples free of charge upon request, but lately, there has been a move to charge a portion of the cost to the requesting party.

CGIAR-affiliated gene banks distribute more than 100,000 samples per year, underscoring the importance of these facilities. Of these, about 28,000 per year are rice. However, the genetic materials mainly go to researchers and plant breeders seeking genetic traits to create new crop varieties. Rarely, if ever, can small farmers access the gene banks.

2.2 The Svalbard Gene Bank as Backup

The Global Seed Vault in Svalbard was built by the government of Norway and was officially opened on February 26, 2008. The facility is carved 70 meters deep into icy mountains with a natural freezing temperature that protects the samples, even during power loss. It has the capacity to hold three million samples.

The objective of the Svalbard facility is to store duplicate seeds from 1,400 genebank facilities throughout the world, with priority going to the CGIAR network. Also called the Doomsday Vault, it is intended as a backup of seeds and other propagules, in order to protect seed biodiversity against major catastrophes such as natural disasters, radioactive fallout, and war. The Global Crop Diversity Trust, a Rome-based endowment fund initiated by FAO and the CGIAR operating with a US$30 million grant from the Bill and Melinda Gates Foundation, covers the costs of preparing, packaging and transporting CGIAR seeds to the Svalbard facility. The responsibility for testing seed viability and for subsequent regeneration and multiplication remain with the gene banks that deposited their seeds in Svalbard.

2.3 Limitations of Cold Storage Gene Banks

The current focus on cold-storage gene banks gives the mistaken impression that they represent the optimal approach to seed conservation. Besides the gene bank approach's inherent technical and economic problems, it ignores more practical and effective methods of on-farm conservation by farmers. Worse, it actually undermines farmers' capacity and right to conserve and improve rice varieties.

2.3.1 Economic concerns

Cold-storage gene banks are very expensive. The overall capital cost to conserve the rice accessions in IRRI in perpetuity is estimated at US$4.1 million and the overall capital cost to distribute in perpetuity is US$8.5 million, giving a total of US$12.6 million.

In addition to the capital cost, there are high maintenance costs. The cost of electricity for two chambers of rice storage at IRRI alone is over US$15,000 per year. Thus, the CGIAR gene banks, IRRI included, have secured a trust fund, the Global Crop Diversity Trust, with support from the Gates Foundation. Nevertheless, institutions maintaining cold-storage gene banks worry about sustaining their funding, as funding priorities of public and private donors inevitably change over time while the objective of gene banks is to maintain genetic diversity in perpetuity.

2.3.2 Technical and ecological concerns

Highly centralized facilities such as cold-storage gene banks are vulnerable to fire, social strife, natural disasters and other disasters, and malfunctioning. Even a double backup of generators for providing electricity during a power outage does not guarantee the integrity of the contents, as experience in other gene banks has shown. For instance, when the Germplasm Institute in Bari, Italy, among the ten largest gene banks in the world, experienced malfunctioning of its cooling systems in 2002, it took several days to fix due to technical and political reasons (Perrino, 2005).

Handling during regeneration and seed processing can cause seed mixing and other types of contamination. Many accessions have died in storage, and countless others have lost their unique characteristics or have been genetically contaminated during periodic regenerations (GRAIN, 2002). Many more are rendered useless when basic information – such as the name, place and date of collection, yield, variety, pest and disease resistance – are lost or mixed up with other samples.

Genetic resources are living entities that interact continuously with factors including temperature, solar radiation, water, soil, pests and disease, and farming practices. These interactions result in co-evolution through the continuous selection of genetic materials that are best adapted to the prevailing immediate environment. Ecologically, long-term cold-storage conditions can reduce seeds' vigor and fitness because they are not subjected to actual environmental and climactic conditions. Seeds subjected to long cold storage have 'arrested' physiological processes and can fall into an 'evolutionary dead germplasm' condition. This means that the seeds are kept in a static state while the real environment in each cropping season is changing, thus the genes are not co-evolving with the environmental pressures in the real world. Principles of evolutionary biology suggest that a stored variety brought out from cold storage and grown, say, in an environment that is one degree centigrade warmer or when the wavelengths of incident solar radiation have changed due to altered atmospheric quality, would not grow optimally. Moreover, farmers' knowledge of the myriad of seed varieties dies out as seeds are commodified and developed in isolation from farmers.

2.3.3 Political economy of cold-storage gene banks

Globally, there are divergent perspectives and interests with regard to seed conservation. Developed countries and multinational corporations actively support *ex-situ* conservation in the form of cold storage gene banks and botanical gardens. They argue that without gene banks, most genetic resources would have disappeared or will soon disappear. They argue that gene banks are the most dependable facilities to save biodiversity. However, hidden in these arguments is the issue of unequal access to and control of cold-storage gene banks by industrialized countries and transnational corporations. These parties can readily access seed samples at any time for use as parent material for breeding or for genetic engineering. The annual average flow of more than 100,000 samples from the gene banks of the CGIAR system to researchers and plant breeders from universities and corporations is very clear proof (Koo *et al*, 2004a). Benefit sharing can also be evaded. Political priorities in a country also can affect gene banks through the control of finances or selection of managers.

In contrast, most developing countries and civil societies are more interested in *in situ* conservation. This is based on the understanding that as biodiversity has to continuously evolve along with the environment, biodiversity conservation must be dynamic. Furthermore, farmers' knowledge should be conserved, and this can only be done in farmers' fields themselves. *In situ* conservation helps governments better control against biopiracy and bioprospecting. But most importantly, this approach to conservation maintains farmers' access to and control over seeds at the farm level. With any successful development of the varieties, government and communities can have better leverage for benefit sharing.

The *ex-situ* gene bank strategy raises serious concerns over the issues of ownership and control, and access and benefit-sharing. Farmers, the original developers and caretakers of seeds, are sidelined in this approach and their contributions to agricultural biodiversity go unrecognized.

2.4 Genetically-Engineered Seeds

It has been argued that genetic engineering can be used to save seeds and enhance biodiversity. Some believe that since genetic engineering can create new forms of life, then it enhances biodiversity. In fact, genetic engineering creates genetic uniformity, not diversity. True biodiversity consists of diverse genetic materials well-adapted to their agro-ecological environment and continuously evolving according to natural selection. The products of genetic engineering are either not self-perpetuating or not true to type: the seeds harvested from the crop will not perform as the original plant, especially in terms of yield and uniformity. Likewise, products of genetic engineering are often produced and planted for just one generation, either through terminator technology or patenting. The farmers then have to buy new seeds for every planting.

2.5 *In situ* or On-farm Seed Conservation Approach

Seed conservation was never a concern before seeds became a commodity for sale. Instead of genetic erosion, there was varietal diversification because of observations, experience, and innovation by farmers themselves. Today, with corporations expanding their control over seed stocks and biodiversity loss accelerating, there is an ever-increasing need for seed conservation by farmers themselves.

In situ or on-farm seed conservation means preserving the varieties cultivated by farmers in their original agro-ecosystem. Different varieties are planted by farmers in combination with specific management practices, making seed conservation fully integrated with local crop production. On-farm seed production makes possible the strong interaction between the genetic make-up of the planted varieties, the farmers' practices (production, seed selection and storage), and environmental factors, such as temperature, drought, soil fertility, disease, etc. Because the rice seeds are planted in the farmers' fields, the rice varieties continue to evolve with changing environmental conditions. This dynamism—the process of evolution and adaptation of crops in their original environment—is the main advantage of on-farm conservation (Maxted et al., 1997a). It is sustainable management of the genetic diversity of locally developed traditional crop varieties and landraces by farmers within traditional agricultural systems (Engels and Wood, 1999).

The goal of *in situ* conservation is not only to preserve varieties or genotypes (i.e. diversity per se) but to maintain an agricultural system which sustains crop diversity. In other words, it is an element of biodiversity-based ecological agriculture (BEA), *in situ* conservation is best done through the maintenance of farming systems (Damania, 1996).

A unique aspect of on-farm rice seed conservation is the preservation of farmers' traditional knowledge and skills. Seeds and farmers' knowledge, culture and skills are inseparable in conserving, adapting and using rice varieties.

In many countries, household members' agricultural roles are often defined by gender. Women farmers are largely responsible for the selection and conservation of rice varieties. Seed conservation is traditionally a responsibility of women in South Asia; seed banks are developed and maintained by women in many Latin American countries; and agrobiodiversity is maintained by women in spaces along men's cash crops in sub-Saharan Africa (Khan, 2005). Among indigenous people from the Cordillera in the Philippines, women first select seeds for planting the next season before they harvest the whole field. They have their own criteria like long panicles, fuller grains, many tillers and free from diseases (Mendoza, 2003).

In Indonesia, Thailand and the Philippines, women provide half the total labor input in rice production. Often, for instance, men prepare the land for tilling, women do the weeding and harvesting, and finally the hauling is done by men. The differentiation of farm activities and roles according to gender gives balance to the family/community social structure; both women and men work in the field and contribute to farming.

Figure 1: A farmers' daughter doing rice breeding (Picture courtesy of MASIPAG)

2.5.1 Requirements for on-farm rice seed conservation

There are no sophisticated or expensive requirements for on-farm rice seed conservation. Farmers must understand and appreciate the importance of biodiversity.

This understanding can encourage farmers to participate in and undertake collective action. In most cultural contexts, a farmers' organization is important to provide a mechanism of leadership, tasking and sharing roles and responsibilities in seed conservation.

Organizations are always important in coordinating activities to manage common resources, including seeds, as well as to mitigate common threats. To address potential damage from unpredictable natural catastrophes like typhoons, flooding, droughts, pests, and disease, there is a need for system duplication. This implies that specific varieties must be grown actively in several locations by farmers across agro-ecological zones. Farmers' organizations are instruments of cooperation and coordination among farmers.

2.5.2 On-farm seed conservation approaches

There are two main ways of implementing on-farm rice seed conservation: (i) through seed banks managed by people's / farmers' organizations (POs), or (ii) considering all farmers as component units of community rice seed banks.

a. PO/NGO-managed community rice seed banks

Farmers' organizations and development NGOs involved in *in situ* rice seed conservation maintain community seed banks in trial farms. This approach involves a few dozen to more than a thousand rice varieties planted in a trial farm cum seed bank year after year. An NGO rice seed bank is managed by its staff while a PO rice seed bank is managed and maintained by the organization's members.

Contrary to the common notion that on-farm rice seed banking means the storage of rice seed reserves, it is rather the complete annual cycle of planting, maintaining, harvesting, processing, and storage. The objective is to conserve the TRVs and to provide farmers access to seeds and genetic diversity. Thus the role of community seed banks is very important, especially for the poorest of farmers who face chronic seed insecurity.

Seed banks cum trial farms also serve as an entry point for organizing other farmers and building their capacity. For example, other farmers and organizations become active in rice seed development through participatory and farmer-led plant breeding. During field days on trial farms, usually before harvests, other farmers are invited to observe and evaluate, after which farmers may be able to take some seeds from the varieties selected.

A seed kit, usually a complement of TRVs and improved rice varieties numbering at least 50 with relatively small samples of seed (1 tablespoonful or 100g of each variety) is usually given to other farmer organizations which are willing to establish their own trial farms. This ensures varietal adaptability as well as availability and diffusion of seeds in the communities.

To establish a PO/NGO-managed seed bank, farmers and development workers have to pool all available TRVs. Sourcing from networks of other development workers will also enrich the seed collections. Collection expeditions are another technique, although they require time and resources. Seed exchanges, field visits, and harvest festivals are effective means of sharing and distributing seeds to other farmers.

b. Farmers as part of community rice seed banks

The most practical and sustainable form of seed banking considers the rice farmers as component units of the community seed bank. This method is cost-effective because after the harvest, farmers separate some seeds from the crop destined for home consumption and sale for the next planting. Farmers practice many variations of seed selection, handling, and storage, depending on cultural, socio-economic and environmental conditions. Some specialized seed production and storage practices farmers employ include selecting panicles[2] from the field before harvest and storing the seeds in special containers.

At this time of climate change, farmers ensure seed security by doubling the amount of seeds set aside for planting so that whenever a crop fails during the first planting, seeds remain available for replanting. No seeds are wasted, because if the first cropping is successful, the extra seeds can always be milled and consumed.

Improving rice varieties and seed quality is very relevant to *in situ* conservation. "Maintenance breeding" is done by 'roguing' (removal of off-types), rotation

Figure 2: A rice panicle (Picture courtesy of MASIPAG)

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[2] A panicle is a loose, irregularly branched seed cluster.

of varieties, and identifying varieties that are resistant to pests, diseases, drought, flooding, salinity, and other environmental threats. 'Selection breeding' is done by harvesting panicles to be saved as seeds from the best plants before harvest. Farmers usually use criteria such as long panicles, many grains, no empty grains, etc. to identify the best plants. Some farmers improve the milling recovery of a variety by dehulling the grains and selecting grains that have small endosperm with bigger and unbroken grain before planting.

2.5.3 Advantages of on-farm conservation

a. The farmers' advantage

On-farm rice conservation puts the farmers in control of seeds at all times and recognizes their inherent right to seeds as part of their food sovereignty. Seeds are available and accessible at the time of planting and the farmers can avoid expensive seeds produced in the formal sector because seeds are saved from past production. Also, seeds are shared with other farmers, reducing dependence on expensive seeds from seed companies. Consequently, there is greater seed security at the farmer and community levels.

Diverse rice varieties can be selected, developed and maintained by farmers to suit all types of agro-ecological conditions, avoiding the 'one size fits all' monocropping approach from the formal sector. Observations by farmers can lead to further selections and improvements of local rice varieties. Throughout this process, farmers can reinforce their knowledge and improve their capacity. The result is effective conservation of rice seeds.

b. Evolutionary advantages

Greater genetic diversity can be maintained if landraces are planted by farmers rather than being stored in gene banks. Through continuous planting and selection, the immediate environment continuously imposes selection pressures on the crops and the farmer also continuously selects the best populations and varieties at every harvest. This way, only the best-adapted seeds are kept and maintained from year to year.

Diverse traditional varieties, maintained and selected under different agro-ecological circumstances, with their combination of genetic diversity and stability, also

Figure 3: A farmer selecting panicles of rice seeds to save before harvesting the whole field (Picture courtesy of MASIPAG)

offer the most cost-effective way of coping with climate change.

But any conservation effort should not only be for conservation; it should help farmers sustain their livelihoods. This means that there is also a need to increase farm productivity and income through increased yields and reduced costs of production. To this end, biodiversity-based ecological agriculture, incorporating *in situ* conservation, can be an effective means of raising farmers' productivity and income.

3.0 MAXIMIZING THE BENEFITS FROM ON-FARM RICE SEED CONSERVATION

On-farm rice seed conservation is not an end in itself. It must be useful and beneficial for the livelihoods of farmers and their families. Continuous selection, breeding and development of varieties by farmers continually evolve new landraces that are well-adapted to local conditions.

Varietal diversification in space and time through on-farm rice seed conservation has multiple objectives. Some of the ecological aims are to evade pests and disease; enhance soil fertility, provide refuge for beneficial insects; provide soil cover; and modify micro-climates for optimal growing conditions. Diversification contributes to raising family income and helps provide a varied and nutritious diet.

In the Philippines, farmers doing rice conservation through the Farmer-Scientist Partnership for Development (MASIPAG) Network have access to and control over more than 2,000 improved traditional rice varieties. This great variety of rice is an invaluable resource to select locally adapted varieties for every unique agro-ecosystem. For example, farmers have identified varieties that are tolerant to drought, flood, and saline conditions; resist pests and diseases; and have a high tilling capacity, good eating quality and many other agronomic and ecological adaptations. Production costs are lower because the farmers do not have to buy expensive commercial seeds. Farmers have learned how to experiment, select and breed rice using their own criteria. Moreover, when crop failures occur due to climate change-induced flooding or drought, other farmer organizations are able to share their seeds with the affected farmers.[3]

3.1 Enhancing the Seed–Farmer Knowledge Interface

On-farm conservation exists in relation to other social, economic and cultural factors linked with agriculture which together support crop diversity, traditional knowledge and household food security. Vega et al., (1997) argued that the equilibrium between production and conservation in on-farm seed conservation systems must be maintained. Self-sufficiency of food and economic security are also prerequisites for farmers to conserve traditional crop diversity (Maikhuri et al., 1997).

The preservation of cultural systems is as important as the conservation of seeds because domesticated crops are shaped by indigenous knowledge and their uses within local systems. Much of this farmers' knowledge (also referred to as associated knowledge), accumulated over thousands of years, has been lost or gone unnoticed with the advent of modern seeds developed by the formal sector. As noted earlier, seed diversity conservation without farmers may not always coincide with farmers' objectives and criteria (Hodgkin *et al.*, 1993).

To enhance the seed-farmer knowledge interface, varieties have to be given back to the farmers and conserved in different agro-climatic conditions where each and every variety is adapted. With farmers acting as stewards, associated knowledge of the seeds is also revived, enriching specific uses. For example, specific varieties are planted in upland conditions, others are planted because of their resistance to pests and diseases, while still others are used in

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[3] The information on MASIPAG's work and results is derived from the author's more than two decades' experience as scientist partner with the MASIPAG Network and being its current National Coordinator.

drought-prone areas because of their short maturing characteristics. In terms of culinary uses, some varieties (namely, glutinous) are used for special occasions, aromatic varieties are used as gifts, and some colored varieties are used for medicinal purposes. The intimate relationship between farmers and seeds ensure the survival of both.

3.2 The Best Way Forward for Farmers

The risks of not being able to effectively save rice seeds are genetic erosion and the extinction of the world's more than 100,000 rice varieties. This would compromise the stability of rice production and the food security of more than half of the world's population who depend on rice as their staple food. It would affect their economic activities and exacerbate poverty and hunger. Furthermore, rice shortages can cause serious social strife: in 2008, riots over the high price of food occurred in Haiti, leading to the forced resignation of the Prime Minister while lack of access to food caused civil strife that same year in Bangladesh, Africa (Faiola, 2008) and Burma (Linn, 2008) as well.

Saving rice seeds in cold-storage gene banks is expensive and has limited utility. It may be convenient in the short term, but the long-term viability of the seeds is uncertain, especially considering climate change. One aspect however is certain: cold-storage gene banks strengthen corporate access to and control over genetic materials, and therefore their control of agriculture and food systems.

In sum, on-farm rice conservation is best for farmers because it recognizes and strengthens farmers' rights and food sovereignty. Farmers are best placed to conserve, utilize, improve and manage rice seed varieties as they have done since the dawn of agriculture. This way, the most diverse rice varieties can be maintained dynamically. On-farm seed conservation reinforces farmers' seed security because varieties can be accessed easily at no cost and whenever needed.

Figure 4: A farmer inspecting the seeds stored in his community's seed bank (Picture courtesy of Achim Pohl)

Seed security is vital for local and global food security, and essential in the fight against poverty. On-farm rice seed conservation is also effective in adapting to the effects of climate change.

Some grassroots action to save rice seeds has been undertaken by several civil society groups and farmers' groups. The MASIPAG Network has recovered more than 1,000 traditional rice varieties and actively conserved them in its trial farms. More importantly, farmers were taught how to breed rice and do varietal, panicle and seed selection. Another group of farmers in Bangladesh have started doing the same. Farmers and civil society groups from India, Thailand and other countries have also done effective conservation of rice and other crops.

Farmer-led conservation initiatives such as these are the best means of maintaining rice diversity while supporting food security, food sovereignty, gender justice, and climate change adaptation and resisting corporate control over seeds.

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Pesticide Action Network Asia and the Pacific (PAN AP) is one of five regional centres of PAN, a global network which aims to eliminate the harm caused by pesticides and promote biodiversity-based ecological agriculture. It is committed to the empowerment of people especially women, agricultural workers, peasants and indigenous farmers. PAN AP launched its Save Our Rice Campaign in 2003 in response to the powerful threats arising against rice, the staple food of half the world's population. The foundation of the Campaign is the "Five Pillars of Rice Wisdom": (1) Rice Culture, (2) Community Wisdom, (3) Biodiversity-based Ecological Agriculture, (4) Safe Food and (5) Food Sovereignty. The Campaign is dedicated to saving traditional local rice, small rice farmers, rice lands and the rice heritage of Asia. PAN AP Rice Sheets provide relevant information on the threats to rice and are written from the people's perspective. Enquiries may be sent to: panap@panap.net.

MASIPAG is a national network of small farmers in the Philippines widely known for its successful work on farmer-led research and crop improvement initiatives involving conservation and management of the country's rice biodiversity. For more than 20 years, MASIPAG has established itself as an "alternative to IRRI" but with a much broader vision of putting the seeds back in the hands of farmers, and of using their knowledge as starting point in agricultural development.

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