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Management of Plant Genetic Resources for Food and Agriculture in the Philippines: Status and Risks

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Abstract

The Philippines is home to a rich diversity of plant and animal genetic resources, and plays a vital role in preserving global species. Plant genetic resources (PGR) for food and agriculture are conserved *in situ* in national reservations and as a component of the traditional farming systems. *Ex situ* collections of important germplasm have been assembled and maintained since the early 1900s. Specific holding institutions conserve major crops in their genebanks. Most of the PGR initiatives in this country are part of the varietal improvement programs of various institutions. The status of conserving the plant genetic resources for food and agriculture, capability building and R&D initiatives are briefly discussed.

Many problems, however, beset the management of genebanks and the continued existence of some crops is put at risk. The risk factors that predispose the country's PGRs to loss or damages are categorized into natural or environmental, technical, social, and political. Most genebank managers cope with the risks on a case-to-case basis. The experiences highlighted in this report show that strengthening the capacity of holding institutions and genebank managers in PGR management should be pursued. Interagency collaboration is vital in the assessment and management of the risks to PGR conservation in order to maximize the use of physical, human, and financial resources, considering the element of quick response time and the magnitude of the risks.

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Introduction

Crop improvement and development rely on plant genetic resources (PGR) as the initial building blocks of new and improved varieties. To attain food security and agricultural self-reliance, the importance of PGR for food and agriculture (PGRFA) as sources of novel genes become even more pronounced. The value of PGR in the economy of the Philippines and the well being of the people can be gleaned from the efforts of various sectors to manage the conservation and utilization of these resources, despite the problems encountered as well as the looming threats and risks.

This report briefly presents the status of PGR conservation in our country. It highlights the problems and constraints encountered in managing PGR resources, and the ongoing PGR capability building and R&D initiatives through the intervention and/or financial support of the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD). This paper also discusses the risk factors that predispose the PGR in selected crops to a precarious state; recent experiences in managing these risk factors are cited and depicted.

The country: Philippines

The Philippines is part of the Southeast Asian region and has a total land area of 115,830 square miles (300,000 sq. km.) that constitutes two percent of the total land area of the world. The country's 7,107 islands and islets are clustered into three groups: Luzon, Visayas, and Mindanao. Of these, Luzon and Mindanao comprise the two largest islands with land areas of 105,000 and 95,000 sq. km., respectively. Together, they represent two-thirds of the total land area of the country. Climate is tropical, characterized by relatively high temperature and humidity, and abundant rainfall. The combination of complex geological origins, fragmented layout, varying exposures to shifting winds and typhoons, and peculiar rainfall distribution has given rise to the existing complex mix of ecosystems and habitat types in this country.

Population is high (89 million) and unevenly distributed throughout the islands due to geographical, historical and social forces and to the uneven development in various regions of the country. This distribution affects the degree of exploitation of natural resources, and the utilization of PGR.

Its archipelagic character has given the country extensive territorial waters (679,800 sq. km.) and the longest discontinuous coastline in the world. Forest zones account for about 15 million hectares (M ha.) or half of the country's total land area. The agricultural crop areas occupy about 12 M ha. These different marine, aquatic and terrestrial ecosystems harbor a rich diversity of plant and animal genetic resources.

Status of PGR for food and agriculture

The Philippines is one of the biologically richest in the world, with about 52,177 unique species of plants, animals and other life forms. About 67% of these species are endemic and cannot be found elsewhere in the world. Approximately 15,000 plant species have been so far identified within its borders. About 40% of the 8,120 species of flowering plants are endemic to the Philippines. More than 3,000 plant species in the country are used for food, medicine, fiber, essential oil, commercial timber or ornamentals (Altoveros and Borromeo, 2007). However, only about 6% of its natural vegetation remains, and 499 species are listed in the 2004 International Union for Conservation of Nature (IUCN) Red List of Threatened Species (DENR, 2005). Of this number, more than half of the species are plants. Thus, as a mega-diversity country and a biodiversity hotspot, the Philippines plays a vital role in preserving global species.

Crops in the Philippines are ranked in importance according to their contribution to food security, livelihood, and foreign trade. Rice and maize, the main staple crops, are considered the two most important crop commodities of the country. Next in importance are coconut, sugarcane, banana, Manila hemp, and mango, which are important both for domestic consumption and foreign trade.

There are wild plant species essential to food production in the country that have contributed significantly to diversification of agricultural systems. Many of these species are components of forest ecosystems, and the plants are gathered from the forest and buffer zones. However, there are no *in situ* conservation programs *per se* on specific wild plant genetic resources for food and agriculture. Wild species useful for food and agriculture that exist within the 65 protected areas under the National Integrated Protected Area System (NIPAS) are likewise protected and conserved by *fiat* (Altoveros and Borromeo, 2007).

Mangifera, Citrus, Garcinia, Nephelium, Durio, Artocarpus and *Dioscorea* are some examples of these wild species.

PGRFA are conserved *in situ* in national reservations and also as a component of traditional farming systems, such as agroforest/homestead gardens, multi-storey farming system, integrated farming system, diversified conservation farming in sloping lands, or multi-cropped home gardens.

Ex situ collections of important germplasm have been assembled and maintained since the early 1900s. There are 45 government and non-government organizations that hold *ex situ* germplasm collections in the Philippines and a list of these holdings is available only for 40 institutions (Table 1). These collections, totaling 173,205 accessions, are maintained either as seeds, living plants, or *in vitro*. A total of 40% of the total collection has been characterized morphologically, 7% on biochemical properties, 3% on molecular properties, and 60% had been evaluated for insect pest and pathogen reaction, physiological and abiotic stress reaction, and product quality. A list of the germplasm holdings for 40 institutions is available.

Table 1. List of agencies in the Philippines holding germplasm collections and number of accessions held.

AGENCY/INSTITUTION	NUMBER OF ACCESSIONS
BPI-BNCRDC	389
BPI-CRD	275
BPI-DNCRDC	624
BPI-LBNCRDC	884
BPI-LGNCRDC	275
BPI-NMRDC	25
BSU	306
CLSU	355
CMU	707
CODA	661
CSU	5
CvSU	14
DA-ILOILO	84
DMMMSU	254
DOA	1394
ERDB	197
EVIARC	76
IRRI	116,928
ISCAF	24
ISU	29
LAES	78
LSU	31

MMSU	6
NARC	773
NCRC	41
NPGRL	35,492
NPRCRTC	1122
NTA	414
PAES	219
PCA	224
PHILRICE	5861
PHILROOTCROPS	2013
PHILSURIN	580
PICRI	176
QSC	94
RMTU	100
SEARICE	769
SRA-LGAREC	1204
USM	227
WPU	275
National total	173,205

Source: Altoveros and Borromeo, 2007.

Specific holding institutions handle the conservation of major crops, like rice, maize, coconut, sugarcane, and banana. Genebanks of Philippines Rice Research Institute (PhilRice), Crop Science Cluster of the University of the Philippines Los Baños College of Agriculture (UPLBCA), International Rice Research Institute (IRRI), Magsasaka at Siyentista Tungo sa Pag-unlad ng Agrikultura (MASIPAG), and Southeast Asia Regional Initiatives for Community Empowerment (SEARICE) conserve rice germplasm. There are a total of over 5,500 collected and documented traditional varieties of rice in the country, and 4 wild relatives. Philippine rice diversity is attributed to the diversity of ecosystems, cultural management practices, and preferences. For maize, the National Plant Genetic Resources Laboratory (NPGRL) of UPLB – Institute of Plant Breeding (UPLB-IPB) has assembled a germplasm collection of 2,099 accessions; of this number, 389 accessions are farmers' varieties collected from 32 maize growing provinces all over the Philippines. For coconut, the Philippine Coconut Authority (PCA), Visayas State University (VSU) and UPLB hold the germplasm collections, with PCA having national mandate and, thus, the largest collection totalling 264 accessions. In the case of Manila hemp or abaca, there are 773 accessions in one *ex situ* collection in the country, consisting of traditional cultivars or landraces, wild types, breeding lines, and improved cultivars. Only in our country can such diversity in Manila hemp be found.

However, the existence of these crops has faced various threats. In rice, destruction of the natural habitat threatens the continued existence of the natural populations of wild rices. In white and yellow maize, the country's traditional or "native" farmers' varieties have evolved over four centuries of continuous cultivation and may possess many desirable characteristics and adaptations. But these varieties are threatened by replacement of traditional varieties with commercial hybrids. The same is true for banana, which is threatened by the replacement of wild types with cultivated species to increase income. Another threat is the destruction of wild bananas during shifting cultivation, road construction, and roguing. Abaca is further threatened by overexploitation/overharvesting of natural stands as well as land use change. Occurrence of destructive pests and diseases, as well as natural calamities, and the use of a few genotypes contribute to the rapid loss of banana and abaca germplasm. Present stands of the wild type coconuts are endangered by the replacement of wild types and traditional varieties with recommended ones. Likewise, cutting of mature and productive palms pose serious threats to this crop and the industry in general. In mango (*Mangifera indica*) the predominance of only one variety ('Carabao') threatens the existence of minor varieties; and the replacement and cutting down of trees, as well as land use change and habitat destruction, are other threats. In the case of coffee, outbreaks of coffee rust have decimated coffee populations all over the country. There are still pockets of the traditional coffee populations remaining, but most of the varieties currently grown are introductions.

PGR capability building and R&D initiatives

The importance of PGR, in terms of value and use, needs to be promoted so that the public can better participate in their conservation and wise utilization. Toward this end, strengthening the capacity of holding institutions and genebank managers in PGR management has been relentlessly pursued. Moreover, support to PGR-related R&D projects is given priority by PCARRD-DOST under the national science and technology agenda.

Through a survey in 2002 among national agriculture and resources research and development system (NARRDS) institutions conducting PGR-related activities, the UPLB-NPGRL noted that these institutions have a core of staff with scientific training in the agricultural and biological sciences. However, PGR, as a growing field of specialization, requires staff with specific skill and competence, and specialized training on the different aspects of PGR conservation, management and documentation is needed to retool the staff. To address this need, for the past three years, a series of non-formal training courses benefiting 75 researchers nationwide were conducted on the following areas: PGR conservation and management, PGR documentation and information management, and PGR characterization using standard descriptors. A training on PGR valuation for 50 researchers is scheduled in the last quarter of this year.

The Department of Science and Technology (DOST) funds ongoing and new initiatives related to PGR R&D, through the active participation of PCARRD as coordinating and monitoring council. Six PGR-related projects are being implemented by nine different state universities and colleges, Department of Agriculture agencies, and one private foundation. These R&D projects focus on the conservation and utilization of tropical fruits, indigenous orchids, abaca, chickpea, and selected crops with local and international market potential.

The project on collection, conservation, regeneration and re-introduction of indigenous orchids in selected protected natural habitats aims to conserve the indigenous biodiversity of Philippine orchid species, regenerate a portion of the conserved biodiversity through in-vitro culture to produce living orchid plants in quantity, and reintroduce the regenerated diversity of selected species into protected natural habitats. Additional diversity of indigenous orchid species will be collected as seeds in fruit capsules from provinces not covered by the first phase of the project. Selected exportable agricultural crops are being evaluated for adaptability, productivity and optimum growth, and their utilization promoted to interested clientele in a private sector-led project on collection, evaluation and utilization of exportable agricultural products.

A new project on safekeeping crop diversity in the national germplasm repository regenerates and multiplies the seed germplasm collections, rehabilitates the field genebank and assures continuous safekeeping of the germplasm. These objectives will be achieved by complementing the field genebank with other strategies, such as *in vitro* conservation or by maintaining the germplasm inside the greenhouse/ nursery. Regeneration was completed for 100 accessions each of corn, sorghum, tomato, eggplant and pepper. The seeds harvested were all processed and stored in the seed genebank. For the field collections, 557 accessions have been rejuvenated and rehabilitated. These include mango, chico, jackfruit, citrus, *Syzygium* spp, pili, cashew, *Musa balbisiana*, and other botanical collections. I*n vitro* collections involving 403 accessions of edible *Musa*, *Musa balbisiana*, sweet potato, taro and yam were maintained in the tissue culture laboratories.

Conservation and use of tropical fruit species diversity in the Philippines is a foreign-assisted project that aims to establish and enhance genebanks of priority fruit species including their wild relatives; develop and make available database of germplasm holdings; identify elite accessions of priority species for further evaluation; and strengthen capabilities of participating institutions on PGR conservation and management. This project involves fruit species, such as: *Canarium ovatum* (pili), *Garcinia mangostana* (mangosteen) and other *Garcinia* species, *Durio zibethinus* (durian), *Artocarpus heterophyllus* (jackfruit), and their related species.

Two newly approved projects deal with chickpea and abaca. The project on introduction, evaluation, development of package of technology and promotion of chickpea (*Cicer arietinum* L.) in the Cordillera Administrative Region shall collect and characterize chickpea accessions, select outstanding entries and evaluate them in the lowland and upland conditions of CAR. A package of technology for chickpea production and chickpea-based processed products will also be developed. Coupled with promotion through demo farms and field days, the project hopes to facilitate the adoption of chickpea in the CAR and lessen the country’s dependence on importation of this commodity. On the other hand, the project on national multilocational trials of promising abaca bunchy top resistant genotypes shall evaluate the performance of promising disease-resistant abaca varieties/hybrids in different abaca bunchy-top disease - infected abaca areas in the country, and identify stable high-yielding and disease-resistant genotypes that can be released to farmers in all major abaca-growing areas.

Further capacity building and research initiatives are needed towards increasing awareness on the importance and value of PGRFA, using modern approaches to genetic diversity assessment, monitoring of genetic erosion, and assessment and management of risks to PGRFA.

Problems and constraints in managing PGR

Many problems beset the management of genebanks, foremost of which is funding. Most of the PGR initiatives in the country are project-based, and the activities on collecting, characterization and conservation are part of an institution's varietal improvement programs. The lack of full government and institutional financial support results in incomplete and fragmented efforts in collecting, characterization and conservation of PGR. Inadequate funding affects the entire management spectrum, from personnel, facilities, to number of accessions maintained or size of collections.

There are other problems and constraints commonly encountered but genebank managers devise practical solutions to address them. Some of these problems and solutions employed are:

- Costly conservation of germplasm collection in field genebank, cold storage and in vitro culture particularly with regard to highland crops or semi-temperate crops – Possible duplicates were identified to reduce the number of accessions maintained.
- High risk of loss especially in field genebank – Only those with potential traits for utilization are maintained in the field genebank/propagation block. Duplicates were deposited in other genebanks, e.g. in the case of the NPRCRTC, duplicates are with the NPGRL, UPLB, and PRCRTC, VSU.
- Limited/Lack of fully trained personnel/staff for proper characterization, duplicate identification, conservation and maintenance of germplasm collection, and databank manager to handle different kinds of data about germplasm collection, conservation, and utilization – Training of researchers on descriptor development, characterization, conservation, and as genebank curator.
- Limited facilities and equipment for *in vitro* conservation and propagation of germplasm – Only those with potential use are conserved in-vitro; Duplicates were deposited in other genebanks.
- Lack of equipped cold storage facilities for short, medium and long-term storage of germplasm – Seeds of annual vegetable crops are also deposited in UPLB-NPGRL seed storage.

These problems, *per se*, pose a challenge to the sustainable conservation of genetic resources and contribute in part to a genebank's predisposal to risks, as these are a function of vulnerability and capacity.

Risk factors in PGR management

Ong, *et al*. (2002) cautioned that every parcel of land that is converted, cultivated, or developed will likely result in the loss of unique life forms found nowhere else on the planet. Thus, any change in land use poses a risk to the existing biological resources. There is a high rate of biodiversity loss, damage or injury due to high commercial and social demand, and the biodiversity is under constant threat of extinction from over-harvesting or over-collection, pollution, widespread land conversion, urbanization, burgeoning population, and poverty.

In general, the risk factors that predispose PGRs to loss or damage may be categorized into either natural or environmental, technical, social and political; however they are also inter-related and there are cases when their overall impact is aggravated by the combined effects of individual risk factors.

Some of our country's experiences on the risks encountered and the actions taken to mitigate their adverse effects or provide rehabilitation to the damage done are cited and depicted.

Natural or environmental

No matter how well managed a genebank is, when major natural perturbations and disaster strike, the effects on the stored germplasm are catastrophic and may be permanent. Natural calamities often resulting to disasters in southeast Asia include the occurrence of strong typhoons, extreme climatic events such as El Niño and La Niña that bring about long periods of drought and floods, tsunamis, earthquakes, fires, landslides, and volcanic eruptions (SEARCA, 2008). Approximately 27% of the country is vulnerable to drought (DENR, 2005), alternating with floods and typhoons yearly. An average of 19 typhoons per year pass the archipelago from June to December.

- PCARRD has recently released funds to rehabilitate the national genebank at NPGRL because typhoon 'Milenyo' (international code name Xangsane), which had a velocity of 190kph, severely damaged the NPGRL genebank building and facilities in 2006.

Two-meter high mud and floodwater damaged the service units located at the ground floor of the building, including the seed research, morpho-anatomical and germplasm documentation units, the greenhouse for asexually propagated germplasm, and damaged equipment and materials including airconditioners, dehumidifiers, standby generators, and vehicles. About 70% of the genetic materials (350 accessions) stored in the NPGRL were damaged by floodwaters and mud, while 100% of the laboratory's root crop collections were buried in mud, and about 5% of the laboratory's total seed collections were also damaged. The typhoon rendered inoperative the four convirons or cold storage facilities, without which the germplasm lose long-term viability.

- The International Rice Research Institute (IRRI) then came to the rescue by temporarily storing the medium-term germplasm collections of major Philippine agricultural crops. Likewise, the Global Crop Diversity Trust funded the restoration of the genebank, in coordination with Bioversity International, through the International Network for the Improvement of Banana and Plantain Asia Pacific Office. Seed collections such as peanut, sorghum, and maize were repacked and sealed into air and water-tight aluminium foil envelopes. A dehumidifier and two power saws were purchased; two dehumidifiers, two screenhouses, the fruit crops nursery, air conditioning and compressors for the cold storage rooms, and a stand-by generator were repaired. Furthermore, the vegetative root crop, fruit crop, banana, taro, and sweet potato collections were rescued and moved into safer conditions. Unfortunately, parts of the collection were not duplicated anywhere else, and consequently many varieties have been lost forever.
- Other ways by which genebank managers pre-empt the risk from such natural calamities is by yearly rejuvenation of germplasm in field genebank, although this is subject to availability of funds. Another is by a system of repatriation/ reintroduction of traditional/farmers' varieties for re-establishment of the ecosystem.
- PCARRD recently approved a project on safekeeping crop diversity in the national germplasm repository by regenerating seed collections and rehabilitating and rejuvenating the germplasm in the field genebank. Continuous safekeeping of the germplasm is assured by complementing field genebank with other complementary strategies (i.e. *in vitro* conservation, maintaining the germplasm inside the greenhouse/nursery).

- On the other hand, those damaged by lightning and bush fire were totally replaced, as in the case of the coconut germplasm in Zamboanga. Another case is the first large fire in the dipterocarp forest that occurred in 1983 in the southern part of the country, Mindanao; that incident resulted in near loss of the valuable mossy forest and its biodiversity-rich vegetation. These fires were induced by the prolonged drought attributed to the El Nino phenomenon.

Technical

1. Pest infestation and disease infection – Examples in the past when an early warning system would have mitigated the destructive effects of pest and disease outbreaks are in the case of ring spot virus in papaya that caused the collapse of the local papaya industry; mosaic and bunchy top viruses that threatened the erosion of banana and abaca diversity; tristeza virus that wiped out citrus genotypes; and the black bug infestation in rice. Yearly rejuvenation of germplasm in field genebank is a way to address this concern. But there is a need to devise a system or mechanism for early warning, especially in reference to pest and disease epidemics. Corollarily, failure to detect and quickly remove diseased sample collections poses a risk. Thus, having trained personnel is essential.

2. Insufficient safety duplication – For security of stored material there are some duplications in other genebanks, but these are not sufficient. Examples of collections that are duplicated in other genebanks are rice, banana, mango, sweetpotato, Manila hemp, and coconut. Except for rice, seed collections are poorly duplicated. Insufficient safety duplication is also the case in medicinal plants, some tropical fruits and nuts, and industrial crops. Meantime, some institutions do yearly rejuvenation of germplasm in field genebank; another way is by a system of repatriation/reintroduction of traditional or farmers' varieties for re-establishment of the ecosystem.

3. Loss of information due to inadequate or wrong documentation – A survey by NPGRL found that record books (88%), data sheets and computers are the most common means used for documentation in our country. About 69% of the holding institutions have computers that can be used for documentation, but these are not fully dedicated to their PGR unit. In the institutions with computers, only 22 (54% of total) have their data encoded, and 19 (46%) have not yet encoded their germplasm data. Only four out of 44 institutions have their own database management systems. The other

institutions have their data recorded manually. Some do not have written data; the information about their collections is kept mentally by the researchers. In some institutions, basic information about the collections is lacking, specifically passport data such as the place of collection, acquisition date, local name, and pedigree. Retrieval of information about their collection may be tedious and some vital information is therefore lost.

4. Failure to collect genetic material and capture *in situ* genetic diversity before it is lost – Factors such as urbanization, land use change and climatic events, agricultural intensification and the replacement of traditional varieties with modern ones can result in loss of the genetic material before it is collected, characterized and conserved.

5. Inadequate/poor storage facilities – Only 4 of the institutions that conserve by seeds have cold storage rooms. In the absence of cold storage rooms, several institutions maintain their seeds in air-conditioned rooms, chest freezers, or under ordinary room condition. Of the 48 different institutions, 17 have tissue culture laboratories conducting normal growth conservation and micropropagation. Of the 17, only 5 are employing slow growth conservation. Only one institution conserves germplasm by pollen, and this is used primarily for its breeding program.

6. Absence of established methodologies for assessing plant genetic erosion – The threat of genetic pollution or introgression, either from genetically modified organisms (GMOs) or from conventionally bred crops to wild species, has become an increasing potential risk to the *in situ* genetic conservation of crop wild relatives.

Social and political

1. Theft and organized pilferage – Fencing of field genebank or provision of security guard in the experiment station/fields become a necessity especially in cases when theft is rampant. Security operation was intensified and assistance sought from local government units to contain organized pilferage in the genebank.

2. Unstable peace and order situation arising from conflicts, especially in Mindanao – Duplicate collections were established in other institutions.

3. Urbanization – Establishment of the Zamboanga City Free Port and Economic Zone resulted in a request for additional area which will greatly damage the areas covered by the *ex situ* coconut collection. Construction of new roads and road widening

resulted in the boling and/or transferring of all affected palms. – Duplicate collections were established in other institutions.

4. Quarry operations, e.g. the rivers inside the coconut genebank, damaged river banks, as well as road networks have affected the coconut plantations where the coconut accessions are located.

In addition, changes in the relative importance of major crops in the country influence the prioritization for conservation of those crops. These changes can be attributed to the following factors: land conversion, increase in volume of export due to increased global demand, pests and diseases, expanded use and new markets, importation and competition with locally-grown crops, or rehabilitation programs. Corollarily, valuable genetic resources not yet collected and preserved may be endangered by these changes in land use.

For now, most genebank managers cope with the risks on a case-to-case basis. The methodologies for assessing these risks and the mechanisms for preparedness need to be addressed, prioritized and included among the capacity building and R&D efforts of PGR management. In the Philippines, there has been no systematic assessment of genetic erosion of PGR (Altoveros and Borromeo, 2007). There is no early warning system yet for threats to PGR, particularly the agrobiodiversity in the country, and mechanisms for preparedness in handling the risk factors need to be explored. For introduced species, the National Committee on Biosafety of the Philippines has formulated the guidelines for the conduct of risk assessment and biosafety. Interagency collaboration would be vital in managing the risks to maximize physical, human, and financial resources, considering also the element of quick response time.

High probability of success and sustainability of PGR conservation efforts, especially amidst the threats and risks at hand, can only be assured by good management at all levels (local, national, regional), institutionalized mechanisms and structures, and strong sustained support from internal and external sources.

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