SAFEGUARDING AND PRESERVATION OF THE BIODIVERSITY OF THE RICE GENEPOOL

FINAL REPORT

July 2000

Introduction

This final report summarizes the activities conducted under the three main components of the project:

I. Collection and *ex situ* conservation of wild and cultivated rices.

II. On-farm management of traditional rice varieties.

III. Strengthening germplasm conservation by National Agricultural Research Systems (NARS) and Non-Governmental Organizations/Farmer Organizations (NGOs/FOs).

Annual reports for the year 1994-1999 have already been submitted to the Swiss Agency for Development and Cooperation (SDC), with the approval of the Project Steering Committee. These annual reports contain the details of activities under each of the project components, and are attached to this report for reference. The section about on-farm conservation is more detailed given the policy implications of the research.

Project Scope and Implementation

Following approval of the project by the SDC in November 1993, two planning workshops were held at IRRI in early 1994:

- Discussion Workshop on On-Farm Conservation of Crop Genetic Resources (February 24-26, 1994).
- 5-Year Action Plan Meeting (February 28-March 3, 1994).

These workshops developed the broad scope of the proposed on-farm conservation research, and the scale of germplasm collecting and training efforts that would be required to sustain the genetic conservation activities of the NARS.

Collecting rice varieties and wild species was carried out in 22 countries (Table 1). Most of the Asian countries that sent representatives to the Action Plan Meeting did develop active programs over the life of the project. Three countries – China, India, and Sri Lanka – undertook no collecting activities because these had already been largely accomplished.

In Sub-Saharan Africa, the decision was taken to support national activities in many of the Southern African Development Council (SADC) region countries through the SADC Plant Genetic Resources (SPGRC) based in Lusaka, Zambia. SPGRC provided administrative and accounting support to Botswana, Swaziland, Tanzania, Zambia, and Zimbabwe. Mozambique and Namibia received funding directly, and also accounted for expenditures independently from SPGRC. Through the Sub-Saharan Africa Regional Office of the International Plant Genetic Resources (IPGRI), collecting was supported in Uganda and Kenya, and an IPGRI staff member, Mr. Dan Kiambi, participated in collecting missions in these countries as well as some of the SADC countries.

In Latin America and the Caribbean, it was originally envisaged that collecting could be coordinated through the International Center for Tropical Agriculture (CIAT) in Colombia. This approach was never developed further. Discussions were held with officials of the National Center for Genetic Resources and Biotechnology (CENARGEN) in Brasilia, Brazil, but the necessary Memorandum of Agreement/Understanding between EMBRAPA/CENARGEN and IRRI was never concluded. It should be pointed out that the successful conclusion of these discussions was probably affected by the international negotiations over access to and use of germplasm under the Convention on Biological Diversity, and the revision of the FAO International Undertaking. However, extensive collecting was carried out in Costa Rica.

Participation by NGOs in the planning phase was limited, as has been their involvement throughout the project. A farmers' group representative did participate in the Discussion Workshop on On-Farm Conservation, but at the national level in several countries there has been more NGO participation in collecting and training, although not really significant. IRRI has assisted the Philippines-based NGO SEARICE (South East Asian Research Institute for Community Education) in the drying and packing of rice seeds for medium-term conservation in the genebank at the Philippine Rice Research Institute (PhilRice).

With the secondment to IRRI of a population geneticist, Dr. Jean-Louis Pham, from the French research organization ORSTOM (now IRD), and the recruitment of a social anthropologist, the research about on-farm conservation was initiated in 1995. Research partnerships and sites were established in three countries:

Country	Partners	Research sites
India	Indira Gandhi Agricultural University, Raipur, and National Bureau of Plant Genetic Resources (NBPGR), New Delhi	Bastar Plateau, Madhya Pradesh
Philippines	PhilRice	Cagayan Valley, northern Luzon
Vietnam	Huê University of Agriculture and Forestry	Region of Huê

The project achievements for the three components are described in separate sections, and brief analyses of impact and monitoring are also presented.

Project Component I. Collection and *ex situ* conservation of wild and cultivated rices

One hundred and sixty-five collecting missions (and additional collecting activities by extension workers in remote areas not reported as formal collecting missions) were carried out in 22 countries from 1995-2000 (Table 1). The trips lasted from just a few days to several weeks.

A total of 24,718 samples of *Oryza sativa* was collected, and 2,416 samples of 16 *Oryza* species, weedy types and mutative hybrids, and some unclassified samples; there were samples of at least four species from three related genera (Tables 2 and 3). A complete breakdown of the samples by species at the time of preparation of this final report requires further inputs from national partners.

Over 80% of the cultivated rice samples and 68% of the wild rice samples have already been sent to the International Rice Genebank (IRG) at IRRI for long-term conservation (Table 4). Cambodia and the Lao PDR also took the opportunity to send some previously-collected germplasm samples not already duplicated in the IRG, so there is not a complete congruence between the figures in Tables 2 and 4.

The collecting effort in the Lao PDR was particularly impressive, with more than 13,000 samples of cultivated and wild rice now safely conserved in the local genebank and in the IRG. The collecting activities in sub-Saharan Africa focused almost entirely on wild species, and in general the number of samples collected was not high. The resource investment to collect this material was quite high but realistic given the somewhat sparse geographical distribution of the species populations, and the difficulties in collecting. NARS observations on constraints to collecting are listed in Table 5.

Observations by national program personnel on genetic erosion and germplasm collection are presented in Appendices I and II, respectively. Some observations on indigenous knowledge are presented in Appendix III.

Project Component II. On-Farm Management of Traditional Rice Varieties

This section presents the main results and conclusions of the IRRI-coordinated research project for on farm-conservation of rice diversity in the Philippines, in Central Vietnam and in India. It presents how the project was designed, the main results it has achieved, and their implications for the on-farm conservation of rice genetic resources, as well as recommendations on the role that a research institution like IRRI can play in this area in partnership with other stakeholders.

Objectives and implementation of the project

In 1994, IRRI organized a think-tank workshop on the on-farm conservation of genetic resources. The participants agreed on the need to develop the scientific basis for on-farm conservation. The philosophy of the IRRI-coordinated project was presented in a position paper (Bellon *et al*., 1997). As with the conclusions of the workshop, we have consistently argued that although on-farm conservation of genetic resources was strongly advocated in international forums, there was limited understanding of what this approach really meant. We concluded that more research should be conducted to understand farmers' management of crop diversity and its genetic consequences. This was especially true in the case of rice for which very limited knowledge was available. Therefore, the IRRI-coordinated project was designed as a research project, not as an implementation project.

The objectives of the project were defined (Pham *et al*., 1996):

- to increase knowledge on farmers' management of rice diversity, the factors that influence it, and its genetic implications;
- to identify strategies to involve farmers' managed systems in the overall conservation of rice genetic resources.

Identification of study sites and partnerships

Rice is cultivated in four main different agroecosystems: the flood-prone ecosystem, the irrigated lowland, the rainfed-lowland and the rainfed-upland ecosystems. One of the first steps in the project was to identify the ecosystem on which to focus our efforts. The flood-prone ecosystem was too marginal to be the main focus of a project aiming at methodological outputs—although obviously not marginal for farmers who grow flood-prone rice. The irrigated system has been the main target for development of modern varieties, and these have largely displaced traditional ones. The restoration of genetic diversity in the irrigated ecosystem is a valid objective, but much beyond the purpose of on-farm conservation. We did not give priority to the upland ecosystem, although the genetic diversity of traditional upland varieties is well known. Even though traditional varieties are the most important in the upland ecosystem due to the limited impact of modern varieties, this was not chosen because the process of loss of rice diversity is not associated with the substitution of traditional by modern varieties, but by a changes in land use or the substitution of rice by other crops.

Finally, the rainfed lowland ecosystem is where we dedicated most of our efforts. This ecosystem is important in terms of area, production, and number of farmers. Rainfed lowland rice makes up 25 percent of the world's harvested rice area and 17 percent of world production. The impact of modern varieties has not been as strong as in the irrigated ecosystem—one reason being that conventional breeding is not as efficient in unfavorable and heterogeneous environments as in favorable and homogenous ones. The coexistence of traditional and modern varieties makes this ecosystem the most promising for on-farm conservation. However, we also included the upland and irrigated ecosystems for a broad assessment of farmers' management of diversity and genetic diversity among the three major rice ecosystems in the Philippines and Vietnam.

Other selection criteria were related to the possibility of comparing the effect of several factors on genetic diversity and its management, based on the theoretical planning framework shown in Fig. 1. These factors included market integration, ethnic identity and environmental heterogeneity (Table 6). Other factors were eventually incorporated into the research plan but in the planning stages only these were considered in site selection.

A general workplan was elaborated in June 1995 (Bellon and Pham, 1995), circulated within IRRI, sent for comments to the members of Project Steering Committee, and finally endorsed by that committee in December 1995. This workplan served as a framework for the three specific country-based work plans developed with national partners in the selected countries.

The identification of country and study sites came from a pragmatic combination of possible partnerships and scientific opportunities. Exploration trips were made and discussions were conducted with potential NARS partners. This resulted in the choice of three study countries and sites: India (Bastar Plateau, Madhya Pradesh), Vietnam (Huê Province, central Vietnam), and the Philippines (Cagayan Valley, northern Luzon). These sites represent a broad cross section of rainfed lowland and upland farming systems, with a wide divergence in agricultural, policy, and economic conditions.

Partnerships were developed with research institutions and also with the institutions in charge of rice genetic resources in the study countries (Fig. 2). The research partners were the Indira Gandhi Agricultural University (IGAU-IGKVV, Raipur, Madhya Pradesh) and the National Bureau of Plant Genetic Resources (New Delhi), the Huê University of Agriculture and Forestry (HUAF), and the Philippine Rice Research Institute (PhilRice). The Vietnam Agricultural Science Institute (responsible for rice genetic resources in Vietnam) did not participate in the research activities.

The Cagayan valley is in the north of the island of Luzon in the Philippines. The agroecological conditions there are generally diverse, although the overall condition is one of marginal lands within a variable environment. In our study area of the rainfed-lowland rice, the most common land types are the *drought and submergence*, *submergence prone*, or *drought prone* environments. The favorable land types are infrequent. It is a typhoon- and flood-prone region. Tuguegarao is the capital of the Cagayan province. The local network of roads is not sufficient to allow an easy access to all villages known as *barangays.* However, the region is easily accessible by road or air.

The region of Huê, in central Vietnam, is narrow walled with mountain chains to the west along the Lao border, and flushed with sandy areas on the eastern coastline. The narrow coastal plains are the food supply area of the whole region. Most of land, often irrigated, is used for rice. The coastal sandy ridge occupies a rather large area and plays an important role in agricultural production and ecosystem conservation. Because of its rainfed condition, sandy soils with poor water holding capacity, salinity and pest pressures, the yields of rice and other crops (such as sweet potato, groundnut sesame, cucumber, chili, beans) are low. In between the two major economic poles of Vietnam—Hanoi and Ho Chi Minh City—central Vietnam has not benefited from the same economic development. Its isolation is decreasing however, as air and road connections with the other parts of the country improve.

In the state of Madhya Pradesh in central eastern India, the study region of Chhatisgarh was represented by two selected districts, Raipur and Bastar. The Raipur district is very near the regional capital city of Raipur whereas Bastar is rather distant (more than 300 km). Among all our study sites, Bastar was by far the most isolated, and the least affected by Green Revolution technologies. Both areas have irrigated and rainfed rice agriculture, although in different proportions. The net sown area for rice in Raipur is 946,000 hectares, of which 425,000 ha (44.8%) are irrigated. Bastar has a total sown area of 841,000 ha, of which 25,000 ha (2.9%) are irrigated. These figures have not significantly changed in the past 10 years. The presence of irrigation also has an impact on the productivity of rice land. The average productivity in Bastar is approximately 1 t ha^{-1}, and 1.5 t ha^{-1} in Raipur. It is evident that rainfed rice agriculture is important in both the Raipur and Bastar areas, although irrigation, while critical in Raipur, is insignificant in Bastar where drought is the main constraint to rice cultivation.

Multidisciplinarity

The theoretical planning framework (Fig. 1) stressed the need to develop a multidisciplinary approach. The IRRI research team consisted of a population geneticist (Jean-Louis Pham, project team leader, seconded from IRD, formerly ORSTOM) from May 1995-July 2000, and an anthropologist (Mauricio Bellon from March 1995-February 1997, and Stephen Morin from March 1997-June 1999), supported by three assistants (seed collection and field studies, molecular markers, social sciences). This mixture of biological and social sciences was extended to the partnerships developed in the study countries, as NARS counterparts were identified in both areas (Table 7). In all, a dozen NARS scientists participated significantly in the project, and a number of others contributed at a more limited level. Also, extension personnel were largely involved in the identification of study villages and in establishing contacts with farmers and village officials. ● A by-product of the project was to build associations between scientists within collaborating NARS from disciplines that seldom collaborate. In May 1999, the project workshop organized at IRRI provided an additional opportunity to develop links among NARS scientists. ●

Methods were chosen based on the objectives of the research, their cost-effectiveness, and available personnel at IRRI and NARS to conduct the research. The methodologies used during the project included:

- socioeconomic surveys;
- questionnaires on farmers' management of diversity;
- anthropological methods, including semi-structured and unstructured interviews; ● ●
- field seed collections;
- surveys for biotic constraints;
- molecular marker analyses (isozymes, microsatellites);
- field trials.

On-farm conservation: a complement to *ex situ* conservation of rice genetic resources

Depending on which stakeholders are affected, on-farm conservation may aim at different objectives. In all cases, however, the starting point should be an assessment of the actual genetic diversity that farmers maintain, how and why a population evolves, and how diversity is perceived and managed by farmers. The ultimate aim must be a link between farmers' conceptualization and decision-making regarding diversity and the actual genetic effect of these behaviors.

Diversity assessment

Germplasm collection. The seed collecting activities led to collections of local rice germplasm which are now maintained by the national programs (Table 8). These collections are absolutely unique because of the effort made to collect a sample of all the varieties cultivated by all the households in the study. Thus, it was possible to capture the diversity at the village or region of a given variety name. ● ●

Distribution of variety names. Although it does not necessarily reflect the actual genetic diversity, the number of names is a basic indicator for on-farm conservation, as names reflect the units of seed management by farmers. The richness of variety names was obvious at all study sites in the rainfed-lowland ecosystem (Table 9). This demonstrates that farmers still maintain a sizeable diversity of rice varieties, even in agroecosystems in the midst of economic and technological changes (Philippines, Vietnam). In India, the Bastar Plateau is a much more isolated environment where farmers maintain an enormous diversity (more than 100 variety names in 8 villages).

In the Philippines and in Vietnam, the number of varieties maintained at the village level was relatively low. The consequence for genetic conservation strategies is that it would not make sense to develop projects based on a small number of villages. On-farm conservation plans in central Vietnam and in the Cagayan Valley must involve several villages distributed across the target agroecosystem.

We paid particular attention to the distributions of variety names across villages, and to methods to represent them. The categorization of varieties into local and widespread varieties, and frequent and rare varieties can help in designing the conservation priorities (Fig. 3). Also, the shape of the accumulation curves of variety names frequencies facilitates comparison of the distribution of diversity across countries (Fig. 4). While Indian sites appear immediately to be the most diverse, as well with the lowest impact of modern varieties, diversity in the Philippines appears much less balanced than in Vietnam because of the predominance of a small number of varieties. An important conclusion however, is the ability of rice agroecosystems to retain what can be called residual diversity. Besides the most frequent varieties, infrequent or rare varieties may represent an important source of *in situ* diversity.

Molecular diversity. Molecular markers are objective indicators of genetic diversity. ● As such, they can provide arguments for the conservation of particular group of varieties, and inform policy-makers on the genetic consequences of changes in the varietal landscape in agroecosystems. In this respect the respective contribution of traditional and modern varieties to genetic diversity was a key question that we illustrate with the case of Vietnam.

Table 10 shows that in a given ecosystem, the relative contributions of traditional and modern varieties are quantitatively surprisingly similar. The specific contribution of each category of varieties must considered however. Fig. 5 shows that if one considers the allelic diversity for microsatellites, traditional varieties bring alleles that are not found in the modern varieties, particularly in the case where only the most frequent varieties would be conserved by farmers. This does not mean that modern varieties should not be considered an important component of the genetic landscape. Modern varieties also contribute genetic diversity that is not contributed by traditional varieties. In particular one should pay attention to the fact that old modern varieties—almost considered traditional varieties by Vietnamese farmers—are as threatened as the local landraces.

Clearly, the debate is not about promoting modern or traditional varieties because they are modern or traditional. It is about managing and conserving diversity in agroecosystems, whether the diversity comes from traditional or modern varieties.

Not only genetic studies played a role in this assessment. In the Cagayan Valley, anthropological studies showed that farmers conceptualize and manage groups of varieties, rather than individual varieties (Morin *et al*., 1998, Fig. 6). Each of these functional groups fits a particular niche in terms of use. These groups were broadly consistent with those identified from genetic analyses:

- The group of glutinous varieties. These varieties all share the fundamental characteristic of being glutinous varieties. The grains are sticky when cooked. In the Cagayan Valley, glutinous varieties are used for special cakes and sweets.
- The group of short growth duration varieties. This group includes varieties that mature in a relatively short period, usually from between 90 to 130 days. The members of the short duration cluster are all modern varieties. Short duration is a characteristic that is valued by farmers because it allows multiple crops per season.
- The long duration group varieties. Long duration varieties mature in more than 130 days. The group is characterized by traditional varieties. It is possible to further classify the long duration group by recognizing that a major subgroup is the Wagwag types.

The conclusion from this therefore is site-specific management of diversity. Not all varieties, or sets of varieties, have the same value in terms of contribution to the overall diversity and its function. Some varieties may bring specific alleles. Others may be associated with a set of agronomic practices and local knowledge, that are more important in the long term for the conservation of diversity in agroecosystems than varieties themselves. Therefore, the role of research institutions is to assess existing diversity through different approaches and identify its components.

A good example of this approach is provided by the Wagwag varieties found in the Cagayan

Valley. First, these varieties bring a specific contribution to the genetic diversity, as shown by DNA marker analyses (Figs. 7 and 8). Second, they play a particular role in terms of functional diversity. They occupy a particular niche in the economic and agroecological environment compared to other varieties managed by farmers because of their high grain quality and their photosensitivity.

Main factors that affect genetic diversity

Agricultural intensification plays a role in the reduction of genetic diversity. In the Cagayan Valley, a differential impact of modern varieties was observed from the upland to the irrigated lowland ecosystem from a survey of 16 households (4 villages/ecosystem, 4 households/village) by ecosystem (Bellon *et al.*, 1998). The ratio of modern to traditional varieties was 24:61, 20:19 and 43:5 in the rainfed upland, rainfed lowland and irrigated ecosystems, respectively. The analysis of the genetic polymorphism at 16 isozyme loci of 149 accessions of traditional and modern varieties showed that a gradient of genetic diversity was also observed, as the Nei's heterozygosity index was 0.25 in the upland, 0.21 in the rainfed lowland and 0.15 in the irrigated ecosystem.

No clear differences were observed between market-integrated and market-isolated villages in terms of number of varieties maintained on-farm or impact of modern varieties whether in Vietnam, Philippines or India. Obviously, this does not mean that socioeconomic conditions do not matter. At the household level, farmers' economic status determines their access to land, and thus influences their range of options. As shown in Fig. 9, the landholding size of Indian farmers is a limiting condition to the use of diversity. It does not imply that farmers with large landholdings grow more varieties, but that farmers with a small landholding—which in Bastar means fewer and therefore less diverse plots—do not grow many varieties. At the other end of the scale, the low level of diversity maintained by farmers with large landholdings reflects the fact they usually own more favorable land.

At the village or district level, socioeconomic conditions matter when they have an impact on rice environment. As we will show later, the development of irrigation is a major factor that affects the use of diversity by farmers. Within a given ecosystem, environmental conditions are the basic factor that influences the level of diversity on-farm. Adverse and heterogeneous biotic and abiotic conditions (rainfed-lowland ecosystem) promote the use of a various set of varieties, most of them being traditional varieties, by farmers:

- in eastern India, our studies clearly demonstrated that farmers manage a pool of varieties to match agroecological conditions and reduce risk and optimize resource use (Morin *et al.*, 1999). Most specific varieties, i.e. varieties used in a limited numbers of agronomic conditions, are found in the marginal environments; environment imposes variety choice. In marginal situations farmers reduce risk by planting low yielding varieties suited to the prevailing environmental conditions, e.g., tall varieties in *gabhar* situation and short duration varieties in *tikra* (Fig. 10). In more favorable situations farmers are more flexible in their variety choice.
- in central Vietnam, only nine varieties out of 77 are common to the inland and coastal ecosystems. The adverse conditions in the coastal ecosystem determine the continuous cultivation of local varieties tolerant to abiotic stresses (Fig. 11). Among the 54 accessions tested for salinity tolerance, two were found of equal or better tolerance than the best control lines (*Pokali*) and can be useful germplasm for breeding purposes.

Dynamic conservation

A major question about on-farm conservation is its potential to preserve the dynamic processes of genetic evolution. Although variety mixtures are not intentionally planted as often in the rainfed lowland as in the upland ecosystem, genetic polymorphism was observed in a number of the variety populations in India and the Philippines, indicating that conditions are met to promote genetic recombination, and therefore genetic changes. Indeed, controlled experiments at IRRI suggested that outcrossing occurs preferentially between plants in the same plot, rather than between plots (Reaño and Pham, 1998).

In the Cagayan Valley, genetic analyses demonstrated that some landraces include very different genotypes while other landraces are specific, well-defined genetic entities. This has important consequences both for *in situ* and *ex situ* conservation strategies, as targeted varieties may not be correctly sampled with a single accession. The analyses also showed slight genetic differences among collections with the same modern variety name (Figs. 12a and 12b). Comparison of the farmers' varieties with those derived from breeders' seed also indicated a divergence between the two samples. These results indicate a high degree of outcrossing among farmers varieties and/or the misnaming of several varieties (Sebastian *et al*., 1998).

In India, we studied the genetic variation within two popular traditional varieties *Safri* and *Sathka*. In both cases, a large intravarietal variation was observed, indicating that not all *Safri* or *Sathka* samples are identical. Several factors have brought about this variation. Misnaming of varieties by farmers is only one of the factors, that could account for extreme differences. For both *Sathka* and *Safri*, one dominant genotype or cluster can be identified, that can serve as the reference cluster. The molecular characterization of the variety group *Sathka* showed that accessions originating from the same village tend to cluster together (Fig. 13). It suggests they result from local processes of genetic differentiation. This is supported by the results from agromorphological characterization.

Thus, it appears that farmers' management of rice diversity is a dynamic process with associated genetic changes. It suggests that in some locations, even after thousands of years of cultivation, the contribution of traditional management of rice diversity to the evolution of the crop is still considerable.

Two approaches to on-farm conservation

Here, we give examples that link the reasons why farmers maintain, discard or lose diversity, and a given on-farm conservation strategy. We believe that most, if not all, on-farm conservation strategies can be categorized under two main principles.

1. <u>Make diversity a viable option to farmers</u>

There is general consensus that farmers are not conservationists in nature, but are conservationists through use. In other words, farmers have to be provided with the right technical and economical options, so that they see the advantages for growing the varieties targeted by the conservationists. Creating conditions that makes diversity a viable option for farmers, either through policy or market mechanisms, is a potential means to promote on-farm conservation. This includes changing existing policy, or reducing incentives for programs that may negatively affect rice diversity.

Promoting long-duration varieties. Although agroecological and socioeconomic conditions can be met where traditional and modern varieties coexist, changes in those conditions increase the tension between traditional and modern varieties. The competition between traditional and modern varieties is aggravated when their respective niches are modified. For example, in the Cagayan Valley, the predominance of high-quality traditional varieties (Wagwag ●) is affected by the increased adoption of high-yielding varieties due to the development of irrigation. The higher market price for traditional varieties does not compensate their lower yield and longer duration. Farmers will continue to grow these traditional varieties if their cultivation does not penalize them.

The idea of investigating new cropping patterns came from the observation of the practices of a farmer who was planting his traditional varieties in late October, a full 3 months after his neighbors. According to him, this practice posed no risk and he felt he achieved higher yields with his traditional varieties than his neighbors. Field trials conducted on the IRRI Experiment Station in Los Baños confirmed these observations. Not only did a late planting decrease the duration of the Wagwag varieties, but there was an increase in yield (Figs. 14a and 14b).

It is then possible to propose a new cropping pattern, that would allow farmers to do double-cropping with both modern and traditional varieties (Fig. 15). Small-scale on-farm trials were conducted in Cagayan in collaboration with the local agricultural authorities. They confirmed the potential of the approach and revealed the interest of farmers. IRRI and PhilRice are developing a project—with the possible involvement of community-based organizations—in which large-scale tests will be conducted. As for any released technology, it will be extremely important to assess the potential impact of this double-cropping pattern, its benefits as well as its possible pitfalls (e.g., occurrence of pests and diseases).

Viability does not only encompass economic aspects. In Vietnam, national researchers are conscious that local varieties play a significant role in the sustainability of the coastal ecosystem that could be potentially harmed by the introduction of high-input varieties. We believe that in central Vietnam, future work will have to address the difficult question of the ecological benefits of agrobiodiversity. Contacts with teams working on natural resources management have been initiated (IRRI-IRD, CIRAD).

Finally, the interest and potential of the diversity of rice varieties must be understood by local authorities, so that diversity management does not conflict, as far as possible, in the practices recommended by agricultural extension agents. In this respect, two workshops were held, in the Philippines and in Vietnam, to present the outputs of our research to local authorities and agricultural officers, and increase their awareness of the existing rice diversity and its value in their activity area. ● ● ●

2. Strengthen farmers' access to diversity

Understanding the external factors of genetic erosion. Our studies demonstrated how fast genetic erosion can occur at the local level. Surveys in the Cagayan Valley showed dramatic changes in the pattern of variety distribution because of two major weather phenomena. In 1997, El Niño caused a severe drought that affected the Cagayan Valley and much of the Philippines. The total amount of rain in 1997 was lower than usual and the timing of rains that did come was not good. The drought came when the rice plants were at the seedling stage, a stage when the tolerance to drought is negligible. Some farmers who had decided to wait for more rains could never plant. In September and October 1998, the typhoons Loleng and Iliang hit the valley and caused severe infrastructure damage ● and early season flooding. ● The level and intensity of these floods was devastating. Again, rice seedlings were lost and even plants at later growth stages were badly affected.

Our surveys demonstrated that these catastrophes had a major impact on the frequency of traditional and modern varieties in Cagayan. The use of traditional varieties by farmers decreased from roughly 45% in 1996 to about 25% in 1998 (Fig. 16). In several villages, the cultivation of traditional varieties was almost abandoned by farmers. Surveys and discussions with farmers and extension agents provided four main explanations for this rapid change in the varieties grown by Cagayan farmers:

- Deficient household seed storage technology: due to the humid climate conditions, the normal seed storage conditions in farming households in Cagayan do not permit farmers to conserve the germination ability of seeds more than 6-9 months. This means that farmers cannot jump a production season; if they do not produce seeds for a given variety during season *n*, they will have to find an external source to get seeds to be able to plant the variety in season *n+1*. Obviously, another option for them would be not to plant the variety.
- Lack of infrastructure for seeds of traditional varieties: in a situation where seed stocks of most farmers were affected, farmers had to rely on external sources to obtain seeds for the next planting season. The seed stores generally carry only modern varieties and certified seed growers, a part of the Department of Agriculture's system of seed procurement strategy, grow only modern varieties.
- Support to the use of modern varieties: in 1997 and 1998 the Municipal Agriculture Offices sponsored a 'plant now pay later' scheme. In this program farmers are given

seeds at no cost, but upon harvest are expected to pay for them. The seeds given in the scheme are from the certified seed growers and are always modern varieties, and sometimes only the recommended varieties. The varieties available in 1998 were IR66 and PSBRC28, the former a popular but older modern variety, and the latter is a new and currently recommended variety. Traditional varieties are not planted by certified seed growers and were not included in the scheme.

- Resilience of irrigated plots: the varieties that were planted in irrigated plots were obviously less affected by the drought than the varieties planted on rainfed plots. Therefore, irrigation sustained the use of the modern varieties, as farmers plant only modern varieties in irrigated plots (Morin *et al*., 1998).

What is remarkable here is that genetic erosion was caused by factors that 1) are external to the farmers' decision-making process, and 2) accompany the release of improved varieties, but are not related to the intrinsic qualities of improved varieties.

Improving on-farm storage. As discussed in the analysis of the consequences of the natural catastrophes in Cagayan, poor storage conditions are a cause of genetic erosion. We are developing a simple and cheap seed drying and storage device that farmers could use to store the seeds for several years. With a simple plastic drum as a container, and toasted rice seeds as a drying medium, preliminary tests show the moisture content of fresh-harvested seeds can be brought down to 10%, i.e., to a level that would permit the conservation of seeds in the closed drum for several years. A prototype of the device is currently being tested by pilot farmers in collaboration with local authorities.

Restoring diversity. In November 1998, we went to Cagayan Province to take seeds back to farmers who had participated in our project. The seeds had been collected from farmers in 1996 and planted and characterized at IRRI in 1997. A total of 28 varieties, including both modern and traditional types, were distributed to farmers in 15 villages. In all, about 1.5 t of seeds were given away. A total of 609 bags of modern variety seeds (2 kg each) and 105 bags of traditional variety seeds (1 kg each) were distributed. ● It appeared two years later that the small amount of seeds distributed to each farmer had limited the efficiency of the distribution. The small multiplication plots implemented by individual farmers were affected by localized floods, while larger plots, possibly conducted at the community level, would have been more resilient. Only 57% and 32% of the bags of modern and traditional varieties respectively, were successfully multiplied. Nevertheless, the distribution modified the on-going downward trend of farmers growing traditional varieties (175 in 1996, 110 in 1997, and 84 in 1998), as it went up to 148 in 1999.

The distribution of seeds we organized in September 1998 demonstrated the interest of farmers in getting back seeds from varieties they had lost. It provided an example of a potential link between farmers and genebanks. Although this distribution was not organized in response to the catastrophes in Cagayan, its impact illustrates the need for genebanks to develop an expertise in the restoration of local diversity. One of the activities included in the FAO Global Plan of Action that was adopted at the Leipzig conference in 1996 is assistance to farmers in disaster situations to restore agricultural systems. The example of the Cagayan Valley shows that disasters do not necessarily happen on a very large scale. The design and logistics for local operations of diversity restoration might have to be very different of those conducted at a national or regional level.

As shown by our study in Cagayan, strengthening farmers' access to diversity can be addressed through adequate policies (e.g., seed growers for local varieties), improved on-farm seed storage at the household or community level, and distribution of seeds from genebanks.

In central Vietnam, another approach has been initiated with the joint support of AUPELF (Network of Universities of Francophone Countries). Three composite populations have been created by bulking seeds from the samples collected in the region of Huê: one population made from the inland area varieties, and two populations made from the coastal area varieties (short- and mid-duration varieties, mid- and long-duration varieties). After one cycle of multiplication in the experimental station, these populations were split into sub-populations and distributed to 10 pilot farmers to be grown every year. The first on-farm multiplication cycle has just been successfully completed. The objective of this experiment is:

- to make the overall diversity of the Huê region accessible to the farming communities and scientists in an easily manageable form to compensate for the lack of storage facilities in villages as well as in the university;
- to establish the basis for dynamic management of artificial rice populations.

Recommendations

On-farm conservation of rice genetic resources, as a complement to *ex situ* conservation can be motivated:

- by the high level of genetic diversity still maintained and managed by farmers, particularly in adverse and heterogeneous environments of the rainfed-lowland ecosystem;
- by the maintenance of agronomic practices and associated local knowledge;
- by the resilience of dynamic processes of genetic evolution in particular areas.

The role of research institutions is:

- to assess existing *in situ* on-farm diversity and its structure;
- to understand the functional role of this diversity (agronomic, socio-cultural, economic, ecological);
- to understand the processes and knowledge associated to this diversity;
- to assess the potential consequences of a loss of diversity;
- to assess the potential benefits of this diversity both to farmers and conservationists;
- to provide development agencies with a framework of understanding of the on-farm diversity in their area of action.

Make diversity a viable option to farmers. On-farm conservation cannot be imposed on farmers. Farmers will maintain or increase the diversity they grow if this brings them benefits. Obtaining the right balance of incentives for farmers to maintain diversity is critical for policy makers and researchers.

The role of research institutions is:

- to identify endangered varieties or variety groups, and the threats to these varieties;
- to identify technical or policy opportunities for the continued cultivation of these varieties (or to change policies that negatively affect diversity);
- to contribute to the transfer of knowledge/technology to farmers through the appropriate channels.

Strengthen farmers' access to diversity. On-farm conservation cannot rely only on the traditional seed exchange mechanisms between farmers that have ensured the continuous cultivation of varieties over centuries. Strengthening farmers' access to diversity is an obvious mechanism to promote diversity on-farm. Farmers should be able to plant the varieties they want, when they want. Enhancing what we call the seed infrastructure is a necessary goal in the maintenance of diversity.

The role of research institutions is:

- to understand the impact of seed policies on farmers' access to genetic diversity, and warn policymakers about their consequences;

- to understand the technical constraints faced by farmers in conserving genetic resources and to improve or develop seed technologies at the local level;
- to develop channels for the reintroduction of lost varieties when needed, and develop links between farmers and genebanks;
- to develop simple approaches to conserve locally a large amount of diversity (e.g., composite 'reservoir' populations).

Conclusions

The contribution of this IRRI-coordinated project for on-farm conservation has been:

- to bring hard data and facts to the debate on the use and relevancy of on-farm conservation of rice genetic resources, and on the impact of deployment of modern varieties on biodiversity;
- to identify avenues for the implementation of on-farm conservation strategies;
- to explore the role that research institutions could play in the future;
- to develop methodologies and competencies in the assessment of rice diversity and its management by farmers through partnership with national programs;
- to increase the awareness and understanding of issues related to on-farm conservation and the value of local diversity both in NARS and local development agencies;
- to share its experience, with other researchers through the participation to various conferences and meetings, publication of papers, organization of a workshop, and collaboration with other projects.

Project Component III. Strengthening Germplasm Conservation by National Agricultural Research Systems (NARS) and Non-Governmental Organizations/Farmer Organizations (NGOs/FOs)

Support to the NARS was provided in the form of equipment to upgrade genebank facilities or facilitate germplasm collection (Table 11), and training of national personnel on the skills needed to collect and conserve rice germplasm.

Between 1995 and 1999, 48 courses or on-the-job training opportunities were offered in 14 countries and at IRRI headquarters in the Philippines (Table 12). The training encompassed field collection and conservation, characterization, wild rice species, data management and documentation, genebank management, seed health, analysis of socioeconomic data, and isozyme and molecular analysis of germplasm. More than 670 national program personnel were trained. IRRI staff were involved in the management, coordination, and presentation of almost all the training activities.

National perspectives on the benefits of training in germplasm collection, and on-the-job training at IRRI are shown in Tables 13 and 14, respectively. Training was also given to scientists participating in the on-farm conservation research (Table 15).

Project Management and Monitoring

IRRI provided overall financial management and implementation for the project. Regular financial statements were submitted to the donor. The Head of IRRI's Genetic Resources Center, Dr. Michael Jackson, was the project coordinator, assisted by Ms. Genoveva Loresto, project scientist. In several countries such as Cambodia, Lao PDR, Myanmar, Indonesia, and Vietnam, local IRRI Liaison Scientists and country program staff provided additional logistical support for accounting purposes, and the acquisition of capital items.

Project expenditure by major categories and by countries is shown in Figs. 17 and 18. Forty percent of the project funds were expended directly by the national programs to finance collecting and training, as well as purchase capital items. Expenditures for operating costs at IRRI, primarily for the on-farm conservation research, and the processing and conservation of collected germplasm accounted for 7%. Only 1% of the total budget was spent on project monitoring.

A breakdown of the on-farm conservation expenditures is shown in Fig. 19, indicating that almost equal allocations were made to institutes in the three participating countries – India, Philippines, and Vietnam. The higher expenditure at IRRI reflects primarily the genetic and field analyses of germplasm collected in this research in which molecular markers were used to assess genetic diversity.

Impact

The project has substantially met the objectives that were established at its initiation:

- Most of the projected germplasm collection activities have been completed, although some gaps do remain. Unique germplasm has been collected from previously under-explored regions in many of the countries that participated in the project.
- Much of this germplasm is safely conserved in the International Rice Genebank Collection at IRRI. Acquisition issues remain to be resolved with Bhutan, with regard to the finalization of a Material Transfer Agreement with IRRI to permit conservation of samples in the International Rice Genebank.
- Two countries, Costa Rica and Namibia, have specified some conditions for access to germplasm from these countries. Status of germplasm *vis-à-vis* IRRI's agreement with FAO (concluded in 1994) to designate the accessions also has to be clarified. Both Costa Rica and Namibia have indicated that germplasm may not be designated to FAO. Issues of access under the Convention on Biological Diversity may be affecting the rate of duplication to the IRGC from some countries, particularly those in Africa. In other cases, initial multiplication of collected samples has proved problematic and has delayed sending them to IRRI for long-term conservation.
- Genebank standards have been addressed and opportunities taken to upgrade facilities, particularly in seed drying and storage. Training in various aspects of genebank management has enhanced staff capabilities.
- IRRI staff developed data management systems for rice genetic resources for several countries (Lao PDR, Bangladesh, Cambodia, Myanmar, and Malaysia) and provided training in data management and documentation.

National staff perspectives of the benefits and impact of this rice biodiversity project on rice genetic resources conservation, on genetic resources activities more generally, and on broader biodiversity issues, are presented in Table 16.

It is clear that the on-farm conservation research has made an original contribution to the discussions about this conservation strategy, and has identified several policy options and technical issues to address. The research has also influenced other external activities by other organizations, and there have been useful linkages with a number of them as they developed their research projects (Appendix IV).

Publications

Abrigo, G.A. (1999). Gender and rice cultivation in the Cagayan Valley. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Abrigo, G.A. (1999). Seed management in the Cagayan Valley. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Alcantara, A.P., Guevarra, E.B., and Jackson, M.T. (1999). The International Rice Genebank Collection Information System. Poster presented at the annual meeting of the Crop Science Society of America, Salt Lake City, October 31-November 4, 1999.

Appa Rao, S., Bounphanouxay, C., Phetpaseut, V., Schiller, J.M., Phannourath, V., and Jackson, M.T. (1997). Collection and preservation of rice germplasm from southern and central regions of the Lao PDR. Lao Journal of Agriculture and Forestry 1: 43-56.

Appa Rao, S., Bounphanouxay, C., Schiller, J.M., and Jackson, M.T. (1999). Collecting Rice Genetic Resources in the Lao PDR. Poster presented at the annual meeting of the Crop Science Society of America, Salt Lake City, October 31-November 4, 1999.

Bellon, M.R., Pham, J.L., Sebastian, L.S., Francisco, S.R., Loresto, G.C., Erasga, D., Sanchez, P., Calibo, M., Abrigo, G., and Quilloy, S. (1998). Farmers' perceptions of varietal diversity: implications for on-farm conservation of rice. In: M. Smale (ed.), *Farmers, Gene Banks and Crop Breeding*. Kluwer Academic Publishing. pp. 95-108.

Bellon, M.R., Pham, J.L., Sebastian, L.S., Francisco, S.R., Loresto, G.C., Erasga, D., Sanchez, P., Calibo, M., Abrigo, G., and Quilloy, S. (1997). Farmers' perceptions and variety selection: implications for on-farm conservation of rice. *Building the basis for economic analysis of genetic resources in crop plants*, sponsored by CIMMYT and Stanford University, August 17-19,1997, Palo Alto.

Bellon, M.R., and Pham, J.L. (1995). Safeguarding and Preservation of the Biodiversity of the Rice Genepool: Component II: On-farm conservation. Research Workplan. *International Rice Research Institute.* p. 23 + annexes.

Bellon, M.R., Brar, D., Lu, B.R. and Pham, J.L. (1996). II. Rice genetic resources. In: K.S. Fisher (ed.) *Rice Production Systems in the Asian Region. Volumn II. Caring for the biodiversity of tropical rice ecosystems*. Electronic conference on the *Sustainable Development of Rice as a Primary Food* organized by the The Pacific Basin Study Center. Available: http://thecity.sfsu.edu/~sustain

Bellon, M.R., Brar, D., Lu, B.R. and Pham, J.L. (1998). Rice genetic resources. In: N.G. Dowling, S.M. Greenfield and K.S. Fischer (eds.),. *Sustainability of rice in the global food system*. Davis, Calif. (USA): Pacific Basin Study Center, and Manila (Philippines): International Rice Research Institute. pp. 251-283.

Bellon, M.R., Pham, J.L. and Jackson, M.T. (1997). Genetic conservation: a role for rice farmers. In: N. Maxted, B.V. Ford-Lloyd and J.G. Hawkes (eds.), *Plant Conservation: the* In Situ *Approach*. Chapman and Hall, London. pp. 263-289.

Cohen, M., Jackson, M.T., Lu, B.R., Morin, S.R., Mortimer, M., Pham, J.L., and Wade, L. (1999). Predicting the environmental impact of transgene outcrossing to wild and weedy rices in Asia. In: *British Crop Protection Council Symposium Proceedings No. 72 Gene flow and agriculture: relevance for transgenic crops.* pp.151-157.

Dikshit, N., Motiramani, N.K., Pham, J.L., Sharma, S.K., Gauraha, A.K., Morin, S.R., Gautam, P.L., and Baghel, S.S. (1999). Distribution of rice diversity in Madhya Pradesh. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Huê University of Agriculture and Forestry and Genetic Resources Center, IRRI (1996). Report on on-farm conservation research in Vietnam. *Project Workshop Safeguarding and Preservation of the Biodiversity of the Rice Genepool*, December 8-12, 1997, Penang, Malaysia.

International Rice Research Institute and Huê University of Agriculture and Forestry (1996). Safeguarding and preserving the biodiversity of the rice genepool in Vietnam. Component II: On-farm conservation. A workplan for the collaborative research between the Genetic Resources Center (GRC) of the International Rice Research Institute (IRRI) and the Huê University of Agriculture and Forestry, Vietnam.

International Rice Research Institute and Indian Council of Agricultural Research (1997). Safeguarding and preserving the biodiversity of the rice genepool in India. Component II: On-farm conservation. A workplan for the collaborative research between the Genetic Resources Center (GRC) of the International Rice Research Institute (IRRI) and the Indian Council of Agricultural Research (ICAR) through Indira Gandhi Krishi Vishva Vidhalaya (IGKVV), Raipur and National Bureau of Plant Genetic Resources (NBPGR), New Delhi.

International Rice Research Institute and Philippine Rice Research Institute (1996). Safeguarding and preserving the biodiversity of the rice genepool in the Philippines. Component II: On-farm conservation. A workplan for the collaborative research between the Genetic Resources Center (GRC) of the International Rice Research Institute (IRRI) and the Philippine Rice Research Institute (PhilRice).

Jackson, M.T. (1997). Conservation of rice genetic resources—the role of the International Rice Genebank at IRRI. Plant Molecular Biology 35: 61-67.

Jackson, M.T. (1999). Managing the world's largest collection of rice genetic resources. In: J.N. Rutger, J.F. Robinson and R.H. Dilday (eds.), Proceedings of the International Symposium on *Rice Germplasm Evaluation and Enhancement*, held at the Dale Bumpers National Rice Research Center, Stuttgart, Arkansas, USA, August 30-September 2, 1998. Arkansas Agricultural Experiment Station Special Report 195.

Jackson, M.T., De Guzman, F.C., Reaño, R.A., Almazan, M.S.R., Alcantara, A.P., and Guevarra, E.B. (1999). Managing the world's largest collection of rice genetic resources. Poster presented at the annual meeting of the Crop Science Society of America, Salt Lake City, October 31-November 4, 1999.

Jackson, M.T., Javier, E.L., and McLaren, C.G. (1999). Rice genetic resources for food security. Invited paper at the IRRI Symposium, held at the annual meeting of the Crop Science Society of America, Salt Lake City, October 31-November 4, 1999.

Jackson, M.T. and Loresto, G.C. (1996). The role of the International Rice Research Institute (IRRI) in supporting national and regional programs. Invited paper presented at the Asia-Pacific Consultation Meeting on Plant Genetic Resources, held in New Delhi, India, November 27-29, 1996.

Jackson, M.T., Loresto, G.C., and De Guzman, F. (1996). Partnership for genetic conservation and use: the International Rice Genebank at the International Rice Research Institute (IRRI). Poster presented at the Beltsville Symposium XXI on *Global Genetic Resources—Access, Ownership, and Intellectual Property Rights*, held in Beltsville, Maryland, May 19-22, 1996.

Jackson, M.T., Lu, B.R., Loresto, G.C., and De Guzman, F. (1995). The conservation of rice genetic resources at the International Rice Research Institute. Paper presented at the International Symposium on *Research and Utilization of Crop Germplasm Resources* held in

Beijing, People's Republic of China, June 1-3, 1995.

Jackson, M.T., Pham, J.L., Newbury, H.J., Ford-Lloyd, B.V., and Virk, P.S. (1999). A core collection for rice—needs, opportunities and constraints. In: R.C. Johnson and T. Hodgkin (eds.), *Core collections for today and tomorrow.* International Plant Genetic Resources Institute, Rome, Italy, pp. 18-27.

Le Dinh Huong, Pham, J.L., Truong Van Tuyen, Le Thieu Ky, Le Tien Dung, Nguyen Thi Cach, Tran Van Minh, and Morin, S.R.(1999). Characterization of study sites in the Huê region, Vietnam : biotic and abiotic Constraints, Cropping practices. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Le Dinh Huong, Pham, J.L., Truong Van Tuyen, Le Thieu Ky, Le Tien Dung, Nguyen Thi Cach, Tran Van Minh, Morin, S.R. (1999). Distribution of rice diversity in Central Vietnam. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Le Thieu Ky, Le Dinh Huong, Truong Van Tuyen, Le Tien Dung, Nguyen Thi Cach, Tran Van Minh, Calibo, M., Pham, J.L. and Morin, S.R. (1999). Agromorphological diversity of rice varieties in Vietnam. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Loresto, G.C. and Jackson, M.T. (1996). South Asia partnerships forged to conserve rice genetic resources. Diversity 12 (3): 60-61.

Malik, S.S., Gautam, P.L., Pham, J.L., Quilloy, S.M., Katiyar, S.K., Baghel, S.S. and R.K. Katre (1999). Molecular diversity of rice varieties in Madhya Pradesh: Preliminary results. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Morin, S.R. (1997). Social Science and Safeguarding and Preserving the Biodiversity of the Rice Genepool: On-Farm Conservation. Seminar presented at the Huê University of Agriculture and Forestry (Vietnam), April 30, 1997.

Morin, S.R. (1998). Rice variety classification among rice farmers in the Cagayan Valley, Philippines: its utility for on-farm conservation. Presented at IRRI's Thursday Seminar Series, May 28, 1998.

Morin, S.R. (1999). Catastrophes and genetic diversity in the Cagayan Valley. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Morin, S.R. (1999). Local classification of rice varieties in the Cagayan Valley. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Morin, S.R. and Pham, J.L. (1999). General design of the project. Workshop of the participants of the project Sa*feguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Morin, S.R., Pham, J.L., Sebastian, L.S., Abrigo, G., Erasga, D., Bellon, M.R., Calibo, M., and Sanchez, P., and Jackson, M.T. (1998). Integrating indigenous technical knowledge and *in situ* conservation: collaborative research in the Cagayan Valley, Philippines. *Indigenous knowledge for the conservation and management of biodiversity*. Cebu City (Philippines), 4-6 March 1998.

Morin, S.R., Pham, J.L., Sebastian, L.S., Abrigo, G., Erasga, D., Bellon, M.R., Calibo, M., and Sanchez, P. (1998). The role of indigenous technical knowledge in on-farm conservation of rice genetic resources in the Cagayan Valley, Philippines. In : *People, Earth and Culture*. Readings in Indigenous knowledge systems on biodiversity management and utilization. Book Series No. 165/1998. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Department of Science and Technology. National Commission for Culture and the Arts. Los Baños, Laguna, Philippines, 1998. pp. 137-150.

Morin, S.R., Sharma, S.K., Pham, J.L. and Garcia-Belen, M. (1999). Matching Rice Varieties and Agroecological Conditions to Reduce Risk and Optimize Resource Use in Eastern India. *1999 Society for Applied Anthropology Meeting,* Tucson, AZ, USA, Session entitled Farmer and Formal Plant Breeders: Is There a Common Basis for Collaboration?

Motiramani, N.K., Dikshit, N., Pham, J.L., Sharma, S.K., Gauraha, A.K., Morin, S.R., Gautam, P.L., Baghel, S.S.and Katre, R.K. (1999). Agromorphological diversity of rice varieties in Madhya Pradesh. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Nguyen Huu Nghia, Luu Ngoc Trinh, Tran Van Minh, Truong Van Tuyen, Jackson, M.T., Loresto, G.C., Morin, S.R. and Pham, J.L. (1998). Safeguarding and Preservation of the Biodiversity of the Rice Genepool in Vietnam. *Vietnam-IRRI Collaborative Workplan Meeting,* Hanoi, November 11-13, 1998.

Nguyen Thi Cach, Truong Van Tuyen, Le Dinh Huong, and Tran Van Minh (1999). Gender and rice cultivation in Central Vietnam. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Patil, V.K., Moriramani, N.K., Dikshit, N., Malik, S.S., Katiyar, S.K., Quilloy, SM., Morin , S.R., Sharma , S.K., Gautam, P.L., Pham, J.L. and Jackson, M.T. (2000). *Ex situ* and *in situ* conservation of rice biodiversity in Madhya Pradesh, India. Poster presented at the *International Rice Research Conference 2000*, IRRI, Los Baños, March 2000.

Pham, J.L. (1996). An example of dynamic management of plant genetic resources. *Philippine Society for the Advancement of Genetics, 4th National Genetics Symposium Challenges and opportunities for geneticists today: making genes work for you*, IRRI, Los Baños, 19-21 September 1996. pp. 60-71.

Pham, J.L. (1997). Promoting genetic diversity at the farm-level: old problems, new strategies. Seminar presented at the Huê University of Agriculture and Forestry (Vietnam), April 30, 1997.

Pham, J.L. (1997). On-farm conservation of rice genetic resources: the IRRI perspective. *Project Workshop Safeguarding and Preservation of the Biodiversity of the Rice Genepool*, December 8-12, 1997, Penang, Malaysia.

Pham, J.L. (1998). Genetic conservation: the role of rice farmers. Presented at IRRI's Thursday Seminar Series, May 21, 1998.

Pham, J.L. (1999). Describing crop diversity in agroecosystems. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Pham, J.L. (1999). On-farm conservation and farmers' management of rice diversity. *Consultative Workshop Enlarging the Basis of Food Security : Role of Underutilized Species.* MS Swaminathan Research Fundation, Chennai, India, 17-19 February 1999.

Pham, J.L. (2000). Role of molecular biology in the *in situ* conservation of plant genetic resources. *Symposium on In situ conservation of plant genetic resources for food and agriculture*, Hanoi, March 21-22, 2000.

Pham, J.L. (2000). Safeguarding Biodiversity: on-farm conservation of crop genetic resources. Panel discussion on genetic resources. *International Conference on Managing Natural resources*, Delhi, Feb. 14-18, 2000.

Pham, J.L., Bellon, M.R. and Jackson, M.T. (1995). A research program for on-farm conservation of rice genetic resources. Poster presented at the *Third Rice Genetics Symposium*, Manila, October 1995.

Pham, J.L., Bellon, M.R. and Jackson, M.T. (1995). What is on-farm conservation research on rice genetic resources? In: J.T. Williams, C.H. Lamoureux and S.D. Sastrapradja (eds.), *South East Asian Plant Genetic Resources. Proceedings of the Third Southeast Asia Symposium on Genetic Resources*, Serpong-Indonesia, 22-24 August 1995. AARD-KEHATI-IPGRI. pp. 54-65.

Pham, J.L. and Berthaud, J. (1999). Why IRD is interested in on-farm conservation. Workshop of the pa*rticipants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Pham, J.L. and Morin, S.R. (1998). On-farm conservation research: assessing biodiversity and indigenous knowledge. *Workshop of the participants of the IRRI-coordinated project on farmer participatory breeding*. Indian International Center, Delhi, March 23-24 1998.

Pham, J.L., Morin, S.R. and Jackson, M.T. (1998). On-farm conservation of rice genetic resources : IRRI's approach. *Regional meeting for Asia and the Pacific to facilitate and promote implementation of the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture.* Manila, Philippines, 15-18 December 1998.

Pham J.L., Quilloy, S.M., Le Dinh Huong, Truong Van Tuyen, Tran Van Minh and Morin , S.R.(1999). Molecular diversity of rice varieties in Central Vietnam. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Pham, J.L. , Toll, J. and Morin, S.R. (2000). The approach of international genebanks (CGIAR Centres) to the local management of crop genetic diversity. University of Wageningen, CPRO-DLO, in press.

Pham, J.L. and Van Hintum, Th.J.L. (2000). Genetic Diversity in Agroecosystems. University of Wageningen, CPRO-DLO, in press.

Pham, J.L., Bellon, M.R. and Jackson, M.T. (1996). A research program for on-farm conservation of rice genetic resources. International Rice Research Notes 21:10-11.

Pham, J.L., Morin, S.R. , Sebastian, L.S., Abrigo, Calibo, MA, Quilloy, S.M., Hipolito and Jackson, M.T. (2000). Rice, farmers and genebanks. A case study in the Cagayan Valley, Philippines. *International Conference on Science and technology for Managing Plant Genetic Diversity in the 21st century*, Kuala Lumpur, Malaysia, June 1-16, 2000.

Pham, J.L., Morin, S.R. and Jackson, M.T. (1999). Farmers' management of rice diversity and on-farm conservation of rice genetic resources. *Note developed at the request of the Swiss Agency for Development and Cooperation.* IRRI, p. 7.

Pham, J.L., Sebastian, L.S., Sanchez, P., Calibo, M., Quilloy, S., Bellon, M.R., Francisco, S.R., Erasga, D., Abrigo, G., and Loresto, G.C. (1998). Genetic data and analysis in the Philippines on-farm. In: Devra I. Jarvis and Toby Hodgkin (eds.), *Strengthening the scientific basis of in situ conservation of agricultural biodiversity on-farm. Options for data collecting and analysis. Proceedings of a workshop to develop tools and procedures for in situ conservation on-farm*. 25-29 August 1997 Rome, Italy. International Plant Genetic Resources Institute, Rome, Italy. pp. 34

Philippine Rice Research Institute and Genetic Resources Center, IRRI (1996). Report on on-farm conservation research in the Philippines. Project Workshop *Safeguarding and Preservation of the Biodiversity of the Rice Genepool*, December 8-12, 1997, Penang, Malaysia.

Quilloy, S.M., Pham, J.L., Garcia, J.S., Hipolito, L.R., Sanchez, P.L., Calibo, M.C., and Sebastian, L.S. (1998). Varietal classification in rice: do DNA-markers help? Poster presented at the 14^{th} Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines, Cebu City, Philippines ,19-24 April 1998. The Philippine Journal of Crop Science 23 (suppl.1):62.

Rao, S.A, Jackson, M.T., Phetpaseuth, V., and Bounphanousay, C. (1997). Spontaneous interspecific hybrids in *Oryza* in the Lao PDR. International Rice Research Notes 22 (1): 4-5.

Reaño, R. and Pham, J.L. (1998). Does cross-pollination between accessions occur during seed regeneration at the International Rice Genebank? *International Rice Research Notes.* 23(3): 5-6.

Sebastian L.S., Garcia, J., Hipolito, L.R., Quilloy, S.M., Caldo, R.A., Tabanao, D.A., Maramara, G.V., Sanchez, P.L., Calibo, M.C., and Pham, J.L. (1998). Molecular markers: powerful tools for analyzing biodiversity of Philippine traditional and modern rice germplasm. Poster presented at the *14^{th} Annual Scientific Conference of the Federation of Crop Science Societies of the Philippines*, Cebu City, Philippines, 19-24 April 1998. The Philippine Journal of Crop Science 23 (suppl.1): 8

Sebastian L.S., Garcia, J., Quilloy, S.M., Hipolito, L., Sanchez, P.L., Calibo, M.C., and Pham, J.L. (1998). Assessment of diversity and identity of farmers' rice varieties using microsatellite markers. Poster presented at *Plant and Animal Genome VI Conference* , 18-22 January 1998, San Diego, California USA. http://www.intl-pag.org/pag/6/abstracts/105.html.

Sharma, S.K. (1999). Gender and rice cultivation in Madhya Pradesh. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Sharma, S.K., Morin S.R. and N Dikshit (1999). Matching rice varieties and situations in Madhya Pradesh. Workshop of the *participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Thurston, H.D., Salik, J., Smith, M., Trutmann, P., Pham, J.L. and McDowell, R. (1999). Traditional management of agrobiodiversity. In: D. Wood and J.M. Lenné (eds.), *Agrobiodiversity: characterization, utilization and management*. CABI. pp. 211-244.

Truong Van Tuyen, Le Dinh Huong, Pham, J.L., Le Thieu Ky, Le Tien Dung, Nguyen Thi Cach, Tran Van Minh and Morin, S.R. (1999). Farmers' perceptions and variety choice in Central Vietnam. *Workshop of the participants of the project Safeguarding and Preserving the Biodiversity of the Rice Genepool. Component II: On-farm Conservation*. International Rice Research Institute, Los Baños, Philippines, May 17-22, 1999.

Acknowledgements

This project has involved the participation of several hundred persons in 22 countries over three continents. Their active participation, and the sharing of germplasm, information, and experiences have contributed to the successful outputs of the project.

Finally, the funding support from the Swiss Agency for Development and Cooperation (SDC) is gratefully acknowledged.

Table 1. Number of collecting trips conducted (1995-1999).

Country	Number
Bangladesh	12
Bhutan	3
Cambodia	28
Costa Rica	5
Indonesia	8
Kenya	3
Lao PDR	15
Malaysia	13
Madagascar	5
Malawi	1
Myanmar	3
Mozambique	2
Namibia	2
Nepal	3
Philippines	12
Swaziland	3
Tanzania (incl. Zanzibar)	2
Thailand	10
Uganda	1
Vietnam	31
Zambia	2
Zimbabwe	1

Table 2. Number of germplasm samples collected by NARS from 1995-1999.

	No. samples of cultivated and wild rices and related genera											
	1995		1996		1997		1998		1999		Total	
	Cult.	Wild	Cult.	Wild	Cult.	Wild	Cult.	Wild	Cult.	Wild	Cult.	Wild
Bangladesh	137	5	156	13	131		92	12	272		788	30
Bhutan			174		235		81	29			490	29
Cambodia	406	152	619	319	483	631	95				1,603	1,102
Costa Rica						172		120		20	0	312
Indonesia	314	1			236		34	1	9	29	593	31
Kenya						62	30	48			30	110
Lao PDR*	1,996	68	4,055	104	3,867	39	2,402	17	579	1	12,899	229
Madagascar	111	12	109	1	147	2	69		206	3	642	18
Malawi					3	54					3	54
Malaysia	93	1	167	4	307		315	4	435	25	1,317	34
Mozambique					6	20	60	12			66	32
Myanmar			311	1	473		642	53			1,426	54
Namibia						12		5			0	17
Nepal	95	1					2	73	3	50	100	124
Philippines	9	1	242	3	293	4	288	5			832	13
Swaziland						8	1	17			1	25
Tanzania					5	69					5	69
Thailand	541	9	463	3	604	48	362	22	232	2	2,202	84
Uganda						15					0	15
Vietnam	606	4	238		148		324		403		1,719	4
Zambia					2	18					2	18
Zimbabwe						12					0	12
Yearly total	4,308	254	6,534	448	6,940	1,166	4,797	418	2,139	130		
Total											24,718	2,416

* the 1999 total includes some samples collected up to the end of February 2000

Table 3. Wild species and related genera collected from 1995 to 1999 with the SDC-funded rice biodiversity project.

Country	Species	No. of samples
Bangladesh	*O. officinalis*	2
	O. rufipogon	18
	Oryza sp.	3
	Weedy forms	2
	Hybrid	2
	Hygroryza aristata	2
	Leersia hexandra	1
Bhutan	Weedy forms	29
Cambodia	*O. granulata*	1
	O. nivara	642
	O. rufipogon	174
	Oryza sp.	248
	Weedy forms	31
	Hybrid	6
Costa Rica	*O. glumaepatula*	312
	O, grandiglumis	
	O. latifolia	
	Oryza sp.	
Indonesia	*O. longiglumis*	7
	O. meridionalis	7
	O. meyeriana	1
	O. officinalis	9
	O. rufipogon	7
Kenya	*L. denudata*	3
	L. hexandra	59
	Unknown	48
Lao PDR	*O. granulata*	6
	O. nivara	59
	O. officinalis	8
	O. ridleyi	1
	O. rufipogon	32
	Oryza sp.	86
	Weedy forms	35
	Hybrid	1
Madagascar	*O. longistaminata*	13
	O. punctata	5
Malawi	*O. barthii*	32
	O. longistaminata	19
	O. punctata	3

Country	Species	No. of samples
Malaysia	*O. officinalis*	7
	O. ridleyi	1
	O. rufipogon	20
	Weedy forms	6
Mozambique	*O. longistaminata*	25
	O. punctata	1
	Hybrids	1
	L. hexandra	5
Myanmar	*O. nivara*	17
	O. officinalis	5
	O. rufipogon	22
	O. granulata	1
	Weedy forms	9
Namibia	*O. longistaminata*	15
	L. hexandra	2
Nepal	*O. granulata*	1
	O. nivara	24
	O. rufipogon	42
	Weedy forms	57
Philippines	*O. minuta*	1
	O. meyeriana	5
	O. officinalis	6
	L. hexandra	1
Swaziland	*L. hexandra*	21
	Prosphytochloa prehensilis	4
Tanzania	*O. eichingeri*	2
	O. barthii	4
	O. longistaminata	12
	O. punctata	21
	Leersia sp.	20
	Unknown	10
Thailand	*O. rufipogon*	30
	O. nivara	50
	O. officinalis	4
Uganda	*O. eichingeri*	4
	O. longistaminata	3
	L. hexandra	8
Vietnam	*O. rufipogon*	4
Zambia	*O. barthii*	3
	O. brachyantha	6
	O. longistaminata	6
	Leersia sp.	3

Country	Species	No. of samples
Zimbabwe	*O. barthii*	12
	O. longistaminata	
	O. punctata	
	L. hexandra	

Table 4. Number of samples received at the International Rice Genebank at IRRI (as of June 30, 2000).

	No. samples of cultivated and wild rices and related genera											
	1996		1997		1998		1999		2000		Total	
	Cult.	Wild	Cult.	Wild	Cult.	Wild	Cult.	Wild	Cult.	Wild	Cult.	Wild
Bangladesh	179	15			167	6					346	21
Bhutan			154								154	0
Cambodia*	605	212	957	273	492	617					2,054	1,102
Costa Rica										83	0	83
Indonesia					297		8	17			305	17
Kenya											0	0
Lao PDR*	2,228	72	3,996	112	3,872	29	2,402	16	579	1	13,077	230
Madagascar	100	10	83	1	151	1	306				640	12
Malawi											0	0
Malaysia	91		131		278						500	0
Mozambique				17							0	17
Myanmar			265		475		649	8			1,389	8
Namibia				12		5					0	17
Nepal	95	1	1		2	73	3	50			101	124
Philippines			171		206	4	51	7			428	11
Swaziland				8			1	17			1	25
Tanzania										30	0	30
Thailand	201	20	200		200						601	20
Uganda						9					0	9
Vietnam					724						724	0
Zambia				15							0	15
Zimbabwe											0	0
Yearly total	3,499	330	5,958	438	6,864	744	3,420	115	579	114		
Total											20,320	1,741

* includes some germplasm collected prior to the SDC-funded rice biodiversity project

Table 5. Constraints encountered by NARS in collecting rice germplasm.

Country	Constraints
Bangladesh	• Natural calamities (flood)
	• Security problems
	• Shortage of manpower
Bhutan	• Logistics (remote areas)
	• Time constraints of research staff
Cambodia	• Security
	• Lack of transportation
	• Communication with farmers
	• Custom differences
Indonesia	• Unpredictable factors in location
	• Impassable roads, huge waves, landslides
	• Security problems
	• Broad areas
Kenya	• Security problems in north eastern and parts of the country
	• Too much rainfall (El Niño) which made the roads impassable and flooded the swampy areas.
Lao PDR	• Security concerns - some areas could not be covered due to security risk.
	• Lack of communication - some remote areas are accessible only by walking, others by a combination of road, river, and walking.
	• Language - rice farmers speak about 48 languages and not all language were spoken by any one resulting in communication problems.
Madagascar	• Security problems
	• State of the roads
	• Dialect problem
	• Logistic support (boots), lodging problem
	• Communication and information problems
Malaysia	• Timing and security
	• Sometimes logistics
Mozambique	• Lack of camping equipment
	• Poor road network
Myanmar	• Inaccessibility - some areas require combination of transport like boat, car and by foot.
	• Safety and language
	• Difference in time of crop maturity

Country	Constraints
Namibia	• Populations of wild species were not as large so that the sampling strategy proposed could be followed • Seed set was very low, resulting in small samples. • No population was found in one area that was targeted. • Old herbarium records from that area exist.
Nepal	• None
Philippines	• Two critical areas remained uncollected due to very critical peace and order (Lanao). • Unavailable manpower to assist project collection • Typhoons normally delay conduct of collecting for at least one year.
Swaziland	• It was difficult to search for *O. punctata* without a herbarium specimen and due to the fact that there is no taxonomist in the country.
Tanzania	• Collection from the national park was a bit difficult when it came to security and rules governing national parks
Thailand	• Time availability and accessibility to the target areas
Uganda	• Parts of the country were not accessible due to security problems
Vietnam	• Transport and security problems to the remote mountainous areas • Not enough practical experience from collectors: several collected samples lost viability • Difficulty in filling in the SDC-funded project collecting form
Zambia	• None

Table 6. Theoretical comparison matrix to study the impact of three major factors on the farmers' management of diversity in the rainfed lowland ecosystem. In bold are the modalities expected to favor the maintenance of on-farm diversity.

		Market integration			
		Low		*High*	
		Ethnic Identity		Ethnic Identity	
		Majority	***Minority***	*Majority*	***Minority***
Agroecological heterogeneity	*Low*				
	High				

Table 7. List of the scientists who contributed to the on-farm conservation research.

	Coordinator	Social Scientists	Biologists
IRRI	Dr. JL Pham	Dr. M Bellon (95-97) Dr. S Morin (97-99) D Erasga (95-98) Ms. M Belen (from 98)	Dr. JL Pham M Calibo Ms. S Quilloy
IGAU	Dr. SS Baghel (95-98) Dr. RK Katre (from 99)	Dr. SK Sharma Dr. AK Gauraha (97-98)	Dr. Motiramani Dr. SK Katiyar
NBPGR	Dr. PL Gautam		Dr. N Dikshit Dr. SS Malik
HUAF	Dr. Tran Van Minh	Truong Van Tuyen Ms. Nguyen Thi Cach	Le Dinh Huong Le Thieu Ky Le Tien Dung
PhilRice	Dr. L Sebastian	Dr. S Francisco Ms. G Abrigo	Dr. L Sebastian P Sanchez (95-97) Ms. Lorna Hipolito

Table 8. Outputs from seed collections conducted for the on-farm conservation research component.

Region, Country	Ecosystem	Year	No. samples	No. variety names
Huê, Vietnam	Rainfed lowland	Wet season 1995-1996	370	41
		Dry season 1996	311	38
	Upland	Wet season 1997-1988	70	17
	Irrigated	Wet season 1997-1998	69	17
Cagayan Valley, Philippines	Upland	1996-1997	133	58
	Rainfed lowland	1996-1997	420	68
	Irrigated	1996-1997	114	26
Madhya Pradesh, India	Rainfed lowland ecosystem	Wet season 1997		
	Raipur area		89	23
	Bastar Plateau		520	106 + 2 weedy rice samples

Table 9. Variation across study sites in the number of variety name and variety names per village.

	No. villages	No. households/village	No. variety names	No. variety names/village
Huê(Vietnam), dry season	16	10	42	2.7
Huê (Vietnam), wet season	16	10	59	3.7
Cagayan Valley (Philippines)	15	12	72	4.8
Bastar Plateau (India)	8	14	106	13.3

Table 10. Genetic diversity revealed by the study of microsatellite polymorphism of rice varieties in Central Vietnam (15 primers).

	Coastal		Inland	
	Modern	Traditional	Modern	Traditional
Number of varieties (accessions)	23 (41)	26 (71)	30 (50)	10 (17)
Number of observed alleles	86	87	70	62
Nei's index of diversity	0.65 ± 0.17	0.61 ± 0.13	0.47 ± 0.20	0.62 ± 0.09

Table 11. Equipment supplied to participating NARS.

Country	Equipment
Bangladesh	Air conditioner (2), Diesel generator (1), computer (1) Printer (1), Altimeter (2), GPS (1), Camera (1), Bicycle (2)
Bhutan	Deep freezers (2), Laptop computer (1), Printer (1) GPS (1), Altimeters (5), Aluminum heat sealer (1), Photo enlarger (1)
Cambodia	Drying cabinet (1), Computer (1), GPS (1), Camera (1), Deep freezer (3), Filing cabinet (1), Seed file cabinet (1), Altimeter (1), Folding pocket magnifier (2), Photo enlarger (1), Grain moisture tester (1).
China, PR	Computer (1), Printer (1)
Costa Rica	Computer (1), Laboratory & office equipment
Indonesia	Deep freezers (6); Aluminum heat sealer (1), Dehumidifier (4), Drying ovens (2), GPS (1), Altimeters (2), Computer (1), Printer (1).
Kenya	GPS (1)
Lao PDR	Computer (1), Printer (1), Heat sealer (1), Deep freezers (3), GPS (1), Altimeters (7), Camera (1), Moisture meter (1), Germinator (1), Drying cabinet (1), Seed blower (1), File cabinets (4), Angular shelves (8), Motorcycles (18), Office furniture, Aluminum ladder (1), wooden desk (1)
Madagascar	Computers (2), Back- UPS (1), Printer (1), Deep freezer (1), Motorcycle (1), Generator (1), GPS (1), Altimeter (1), computer table (1)
Malawi	GPS (1)
Malaysia	Deep freezers (2), Computer (1), Printer (1), GPS (1), Altimeter (1), Camera (1)
Mozambique	GPS (1), Handlens (1)
Myanmar	Computer (1), Laser printer (1), Aluminum heat sealer (1), Camera with tripod (1)
Namibia	GPS (1)
Nepal	Altimeter (1), GPS (1), Camera (1), Light meter (1), Pocket lens (1), Binocular (1), pH kit Box (1), Camping equipment
Philippines	Aluminum heat sealer (1), Air conditioners (3), Dehumidifier (2), GPS (1), Drying cabinet (1), Moisture tester (1), Camera (1), Computer (1), Printer (1), Dial caliper (1), Thermometer (1), Altimeter (1)
Swaziland	GPS (1)
Tanzania	GPS (2) including Zanzibar
Thailand	Laser printer (1), Vacuum cleaner (1), Seed moisture tester (1), Altimeter (1), GPS (1)
Uganda	Deep freezer (1), Computer (1), Printer (1), GPS (1)
Vietnam	Computers (2), Printers (2), Drying cabinet (1), GPS (1), Aluminum heat sealer (1), Altimeters (2)
Zambia	GPS (1)
Zimbabwe	GPS (1)

Table 12. In-country training course conducted from 1995 to 1999.

Course	Scope	Date	No. participants	Country	Coordinator(s)
Field collecting & conservation of rice germplasm	The course has three modules on the rice plant, the rice genepool and the principle and practices in genetic conservation. A field practical on field collection and writing a field trip report supplements the classroom activities	07 June 1995	16	Thailand	S. Chitrakon
		11-13 June 1996	31	Thailand	S. Chitrakon
		11-16 Sep. 1995	19	Lao PDR	S. Appa Rao/ C. Bounphanousay
		25-30 Sep. 1995	7	“	
		02-07 Sep. 1996	32	“	“
		12-18 Sep. 1996	24	“	“
		25-Sep.–1 Oct. 1996	12	“	“
		14-20 Aug. 1997	21	“	“
		25-30 Aug. 1997	38	“	“
		25-30 Sep. 1997	8	“	“
		21-26 Sep. 1998	22	“	“
		11-12 Aug. 1999	11	“	
		02-07 Nov. 1996	24	Bangladesh	G. C. Loresto/M. K. Bashar
		05-10 Aug. 1996	30	Bhutan	G. C. Loresto/M. Ghimiray
		03-08 Oct. 1997	34	“	
		19-25 Oct. 1998	17	“	
		15-19 Oct. 1996	15	Cambodia	G. C. Loresto/ E. Javier
		24-29 Nov. 1997	16	“	“
		16-23 Feb. 1998	20	Malaysia	G. C. Loresto/ Abdullah Md. Zain
		19-24 Aug. 1996	19	Myanmar	G. C. Loresto/A. A. Garcia
		15-20 Sep. 1997	18	“	
		14-19 Sep. 1998	27	“	“
		18-24 October 1997	7	Nepal	G. C. Loresto/ M. P. Upadhyay
		20-29 June 1995	15	Vietnam	S. Appa Rao/L. N. Trinh
		16-24 March 1998	15	“	G. C. Loresto/L. N. Trinh

Course	Scope	Date	No. participants	Country	Coordinator
Field collecting, conservation & characterization	Describes four modules on 1) the rice plant: morphology & life cycle, 2) the rice genepool, and 3) the principles practices in genetic conservation and 4) field characterization. A field practical on field collecting, characterization and trip report writing supplements the classroom activities	25-30 Aug. 1997	12	Madagascar	G. C. Loresto/Mme. Simone Ravaonoro
		20-28 Apr. 1998	12	"	"
		12-26 April 1997	28	Mozambique	D. Kiambi, G. C. Loresto & P. Munisse
Field collection & conservation of wild species	The scope is the same as those of field collecting & conservation but the focus for fieldwork was on the wild species.	25-29 Nov. 1996	14	Zambia	S. Leide/ D. Kiambi
		27-28 Sep. 1999	16	Indonesia	B. R. Lu/Sudiaty Silitonga
Data management & documentation	The course covers the basic principle of a computer, a database, the Microsoft Access, and Rice Information System (RIS). Hands on exercises were given on the use & implementation of (RIS).	4-14 Aug. 1997	7	Myanmar	E. Guevarra/A. A. Garcia
		21-Nov.-03 Dec. 1997	6	Bangladesh	E. Guevarra/M. K. Bashar
		31 Jul. 09 Aug. 1997	10	Lao PDR	A. Alcantara/S. Appa Rao
		26 Feb.-06 Mar. 1998	12	Cambodia	A. Alcantara/E. Javier
		26 Oct.- 07 Nov. 1998	17	India	E. Guevarra/P.L. Gautam

Course	Scope	Date	No. participants	Country	Coordinator
On-the-job training	Field characterization at IRRI Headquarters	28 Feb.-04 Apr. 1997	1	Bhutan	R. Reaño
	“	18 Aug.-02 Sep. 1997	10	Bangladesh, Cambodia, China (2), Madagascar, Malaysia, Mozambique, Nepal & Vietnam	R. Reaño
	Field characterization at Mahitsy Station, Madagascar	23-28 April 1998	9	Madagascar	G. C. Loresto/Mme. Simone Ravaonoro
	Genebank management at IRRI Headquarters	13 Sep.-10 Oct. 1997	8	Bangladesh, China, Cambodia (3), Madagascar, Malaysia, & Nepal	F. de Guzman
		17 Aug.-04 Sep. 1998	4	China (3), Philippines	“
	Data management	13 Oct.-07 Nov. 1997	3	China, Madagascar, & Malaysia	A. Alcantara/ E. Guevarra
		07-23 Sep. 1998	4	Indonesia (3), Philippines	A. Alcantara/ E. Guevarra
	Isozyme analysis	10 Dec.- 09 Feb, 1997	1	Vietnam	S. Quilloy
		10 Oct.–10 Nov. 1998	1	Vietnam	A. Juliano/S. Quilloy
		19 Oct.-19 Dec. 1998	1	Vietnam	“
	Seed Health	14 Jul.-15 Aug. 1997	1	Cambodia	P. Gonzales
		29 Jul.-29 Aug. 1997	1	China	“
	Analysis of socio-economic data	02-28 Dec. 1996	1	Vietnam	M Bellon

Table 13. Benefits of in-country training to NARS' collecting activities.

Country	Benefits (comments from national personnel)
Bangladesh	• Direct collection of germplasm by some extension and NGO workers using their training experience. • Covering more areas. • Enhancing collecting skills. • Accessing remote areas. • Acquiring awareness of rice germplasm collection.
Bhutan	• The training created awareness on PGR activities and mobilized field workers in collecting activities. • Provided collecting skills. • Covered large and inaccessible areas by trained personnel. • Helped set up a sound PGR program for the country. • Created awareness on PGR at various levels.
Cambodia	• Could assist us to assign activities in big scale. • Were able to collect many samples of cultivated and wild rice species. • Most of the collections are accompanied with passport data as compared to pre-SDC collection. • Allocation of budget was more effective. • Enhanced collecting skill. All collectors can identify wild rice. • Able to plan for collection trip and the way to handle with local custom. • Commitment of extension worker to collect crop germplasm.
Indonesia	• No in-country training in field collections, but in every collecting mission we were assisted by extension workers, so they were trained while collecting. (Note: A two day workshop on field collection of wild species was held in Irian Jaya in September 1999 after this survey).
Lao PDR	• Helped the extension officers to collect germplasm as they had never collected before. • Cover more areas. • Access to remote places which can be reached only by walking. • Trained collectors served as excellent counterpart in their areas. • Overcome language barrier and enabled to get samples and fill collecting forms.
Madagascar	• Use in 1999 - 40% research staff and 40 % extension workers. • Helped in the identification of the varieties • Enhanced collecting skill. • Enhanced contact of useful staff skill. • Enhance knowledge of sampling seeds. • Access to remote areas.
Malaysia	• Increased understanding of GR activities at national and international level. • Increased awareness of the urgency of collecting in remote areas. • Better understanding on the use of genetic resources for future food production. • The group now understood the breath or the spectrum of conservation strategies/programs. • The group now knows the systematic method of collection and reporting of GR activities.

Country	Benefits (comments from national personnel)
Malaysia cont'd.	• Renewed awareness on the usefulness of the traditional rice for rice breeding. Enhanced collecting skills. • Can do better planning to cover more areas. • Enhanced group effort in GR activities among friends/office mates.
Mozambique	• Increased germplasm collection skills. • To start decentralized germplasm program. • Enhanced collecting skills. • Wide ecogeographic coverage.
Myanmar	• Arouse public awareness on the importance of PGR • Cultivate active interaction and collaboration between seedbank staff and extension workers on PGR collection. • Maintaining appropriate passport data on collected PGR. • Upgrade the capacity level of the staff in PGR collection to meet the needs of the job. • Cover areas that have never been explored and collected.
Nepal	• Practical and theoretical task during the training period helped to increase the technical ability on field collection and conservation of rice germplasm. • Enhanced skills on rice morphology. • It covers more areas like rice plant, rice genepool, principles and practices in genetic conservation, etc. • Helps to identify what types of material to be collected within a given area at a given time.
Swaziland	• Workshop in Lusaka - I learned how grasses are collected as I had not done before and also got to know the wild relatives of rice.
Thailand	• Awareness and importance of rice genetic resources. • Cover more areas. • Access to remote areas. • Enhanced collecting skill. • Educate more people.
Vietnam	• It helped the current collecting activities and conservation program on making greater awareness on importance of germplasm collection and on providing skill on collecting techniques to PGR staff and extenuation workers. • Enhanced collecting skill especially in getting information to fill in the collecting form. • More active involvement of extension workers in germplasm collecting. • Help to setting priority for germplasm collection on aspect of preventing the genetic erosion.

Table 14. Benefits of on-the-job training at IRRI.

Country	Benefits (comments from national personnel)
Bangladesh	• Acquired knowledge on the proper management of genebank. • Characterized the germplasm especially wild species efficiently. • Able to establish data base through RIS of Bangladesh.
Bhutan	• Field characterization of collected germplasm has been started by the trained staff.
Cambodia	• Characterization of the collected samples was faster and with more confidence. • Improved management and operation protocols of handling seeds from harvest to storage.
China	• Awareness on global rice genetic resources. • Enhance knowledge on the use of genetic resources. • Able to design and develop a simple rice information system Isozyme analysis is being started to classify rice germplasm and to study genetic diversity to support on-farm conservation.
Indonesia	• Improve the capability of our computer operator in format and design information system. • Develop the data base.
Kenya	• Field characterization of wild species of rice. • Viability testing of wild species. • Designs of Kenya Rice Information System (Not complete).
Lao PDR	• Understood the principles & practices of an ideal genebank management. • Able to manage Lao genebank more efficiently. • Able to store germplasm in a systematic way. • Understood the need for regular monitoring of the seed viability and regeneration of seed to maintain optimum viability.
Madagascar	• Improved genebank management. • Able to input data in the computer. • Improved management of data. • Improved identification of varieties.
Malaysia	• Improve management of seed storage. • Enhanced knowledge on the use of the software programs. • Improved skill in characterization.
Mozambique	• Enhanced characterization skill. • Increased number of accessions characterized.
Nepal	• Increased technical know how on field characterization of rice germplasm. • Helps in managing seed genebank.
Philippines	• Improvement in the overall approach in seed genebanking/ conservation. • Acknowledgement of the need for an electronic data storage system. • Implementation of a simple rice documentation system.
Vietnam	• Isozyme analysis is being started to classify rice germplasm and to study genetic diversity to support on-farm conservation.

Table 15. Training given to participants in the on-farm conservation research.

Year	Participant and affiliation	Length	Topic
1996	Le Dinh Huong HUAF (Huê)	2 months	isozyme analysis biotic surveys
1996	Truong Van Tuyen HUAF (Huê)	1.5 month	socioeconomic data analysis
1998	Nguyen Van Tao Cuu Long Rice Research Institute	2 months	isozyme analysis
1998	Tranh Van Suu Vietnam Agricultural Science Institute	1 month	isozyme electrophoresis
1999	S.S. Malik National Bureau of Plant Genetic Resources (Delhi)	1 month	isozyme electrophoresis
1999	N. Dikshit National Bureau of Plant Genetic Resources (Cuttack)	2 weeks	conservation of genetic resources data analysis
1999	Le Dinh Huong HUAF (Huê)	3 weeks	data analysis
1999	N. Motiramani, Indira Gandhi Agricultural University (Raipur)	2 weeks	data analysis
1999	S.K. Sharma, Indira Gandhi Agricultural University (Raipur)	2 weeks	data analysis

Mr. Truong Van Tuyen received a grant from IRRI to conduct a Ph.D. (1998-2002) at UPLB in Community Development. His research on farmers' management of rice diversity in Central Vietnam is co-advised by M. Hossain and J.L. Pham.

Table 16. Impact of SDC funded project on the conservation program of NARS (national personnel observations).

Country	Impact on rice germplasm conservation	Impact on PGR conservation	Impact on the biodiversity program
Bangladesh	The project helped in the collection of the rice germplasm both cultivated and wild rices preferably from less explored and inaccessible areas when the BRRI's own resources were limited. It also helped in the stored germplasm providing the equipment for genebank maintenance properly. Finally the project provided training for the genebank personnel which enabled them to run smoothly the conservation program of rice germplasm in BRRI.	No comments.	No comments.
Bhutan	Provided training to research and extension personnel, collections from remote areas, and equipment for conservation.	Trained staff will initiate activities on other crops.	Awareness on plant genetic resources and biodiversity.
Cambodia	Most of the existing rice germplasm in the accessible areas have been collected and stored. These collected samples were also characterized for most of the passport data required.	Despite the collection and conservation activities took place mainly in rice, it is a very good exercise for Cambodia to undertake another step in such activities in other crops.	By collecting most of the cultivated and wild type rice, we firmly believe that the preserved materials will be very valuable especially when massive genetic erosion occurs in the country.
China	Six young staff from CNRRI who attended the OJT at IRRI have progressed and widened their knowledge on characterization of wild and cultivated rices, genebank management and conservation, data management and documentation, as well as seed health. They are responsible for CNRRI genebank management and related research activities.	Trained staff were appointed to key positions in the management and research of the national genebank.	No comments.
India	Helped in understanding rice landrace diversity in tribal areas.	Provided clues to the in situ/ on-farm conservation activities and their linkage with *ex situ* conservation efforts.	This has been useful in improving the rice germplasm management.

Country	Impact on rice germplasm conservation	Impact on PGR conservation	Impact on the biodiversity program
Indonesia	Our genebank was improved by adding some equipment, so we can keep the rice germplasm in short, medium and long term. The most important thing, we collected 585 rice germplasm.	Besides collecting cultivated and wild rice, other food crops such as corn, sorghum, legumes and tubers were also collected. Our trained staff also worked for food crops database.	By developing genebank and database management system, we plan to establish National Center for Food Crop Genetic Resources.
Kenya	We were able to collect more diversity of rice and related general species. Trained one member of staff on conservation and management of wild species and in data management and documentation (partial).	Some techniques acquired can be applied to other species being conserved like viability testing of wild species.	We were able to collect a wide range of rice germplasm and their wild relatives previously not included in our collections.
Lao PDR	Since rice is the most important food crop supplying 80% of the calorie intake of the people of Laos, conservation of rice is almost synonymous to conservation of biodiversity. All the samples collected are preserved safely in Laos. Lao PDR now can claim to have a national genebank for traditional rices and wild relatives.	No activity on other crops.	The experience gained in rice can be used to collect and conserve other crops if financial assistance is provided.
Madagascar	The SDC funded Rice Biodiversity project has helped the national program by sponsoring the related training, providing equipment which improves our documentation (computerization), supporting all the expenses for the collecting missions, thus safeguarding our rice biodiversity.	The plant genetic resources conservation program refers to rice germplasm in conservation program as a model for completing its activity.	Until now, conservation of biodiversity program as a whole concentrates its effort on the safeguard of the primary forest and its fauna and reforestation problems, so this project helps us for the safeguard of our rice biodiversity.

Country	Impact on rice germplasm conservation	Impact on PGR conservation	Impact on the biodiversity program
Malaysia	Actually the project has given a tremendous boost in securing the rice genetic resources from the remote areas especially in Sarawak and Sabah because without the budget we were not able to go thus far. Our national project budget is quite small and simply cannot support collections in the areas that we have so far covered. The project also has provided us enough flexibility relating to budgeting to enable the genebank to purchase small essential items (consumables). The project has given us approval to buy PC (on-request during the mid-project duration) to upgrade our documentation capability. As a result we are now ready to use our own management and retrieval system (MARDIGEN) using Dbase 111 software. In addition IRRI is developing for us the RIS for Malaysia. When it is completed, we will use RIS completely. The purchase of 2 units of deep freezers has given an additional space for long-term storage.	The SDC-funded project has triggered a refreshing momentum to the rice conservation program. Without strong financial support by local and international agencies the conservation plan/strategy is quite meaningless, therefore, this kind of cooperation/collaboration is very meaningful to our genebank in particular and our conservation program in general.	The SDC project has strongly helped our national endeavor in biodiversity program on rice germplasm. This collaborative project (activities and results) was highlighted in program meetings/project monitoring and it was agreed that it is an excellent way of fostering international "get together" in biodiversity conservation activities. As one of the important centers of Plant Genetic Diversity, Malaysia is committed and of course such kinds of international assistance have always been very instrumental in enhancing biodiversity undertakings in the past, present and the future.
Mozambique	Training in germplasm collection and field characterization. Rice germplasm collection.	Training in germplasm collection and characterization, and actual collecting.	Rice biodiversity conservation program improved.
Myanmar	The project mainly concentrated on rice germplasm collection.	New germplasm accessions are being added to the genebank conservation program.	Has limited impact on biodiversity program as a whole.
Namibia	Now, we have at least some accessions of wild relatives.	Plus additional GPS.	Expanded the diversity of species conserved ex situ. Pointed out the vulnerability of this species (low seed set, grazed). Showed larger distribution than expected from records available prior to germplasm collection.

Country	Impact on rice germplasm conservation	Impact on PGR conservation	Impact on the biodiversity program
Nepal	Rice germplasm from proposed districts has been collected and conserved with duplicate samples at IRRI genebank.	The activity has supported our National PGR program.	The effort is a part of biodiversity program to be conserved.
Philippines	It has equipped the program thereby greatly improved our conservation activities. There is confidence that we are able to conserve most of the diversity of Philippine rices.	Strong linkage to NPGRL to include rice among the crops that it currently is conserving.	No comments.
Swaziland	This was the first rice collection mission.	We were not even aware that we had rice wild relatives existing in the country. The project was of great help in collecting them.	We were able to collect other wild crop relatives that we came across during the mission.
Tanzania	No comments.	Assisted the national program in the collection activity thus leading in having rice and wild relatives in our genebank.	We have succeeded in conserving a wide range of cultivated rice, wild relatives and related genera.
Thailand	SDC funds have assisted partly to rice conservation program on rice collection activities and collection training.	*In situ* conservation of wild rice.	Coordination on *in situ* conservation of wild rice species and other living organism.
Uganda	Wild rice germplasm was collected and this has served as an eye opener to different stakeholders on the great wealth and resources. We have thus increased support.	The project enabled our national program to have up to date information on the state of rice resources *in situ*.	Thus as we are in the process and preparing the national biodiversity strategy and action plan we have some concrete data to refer to.
Vietnam	It supported the National Crop Genebank to collect rice germplasm in key areas where rice landraces have been under the most serious threat of genetic erosion.	The national PGR program has collected important rice genetic resources and has been provided with valuable training support and valuable equipment.	The program of agrobiodiversity conservation is highly beneficial in making people greatly aware of the importance as well as in contributing to formulate a national strategy on agrobiodiversity conservation.
Zambia	A wider genetic base of rice, both cultivated and wild, is now conserved.	A wider genetic base of the country's crops/plants is now conserved.	No comments.

Figure 1. A conceptual model of the factors that influence farmers' management of diversity (from Bellon *et al*., 1995).

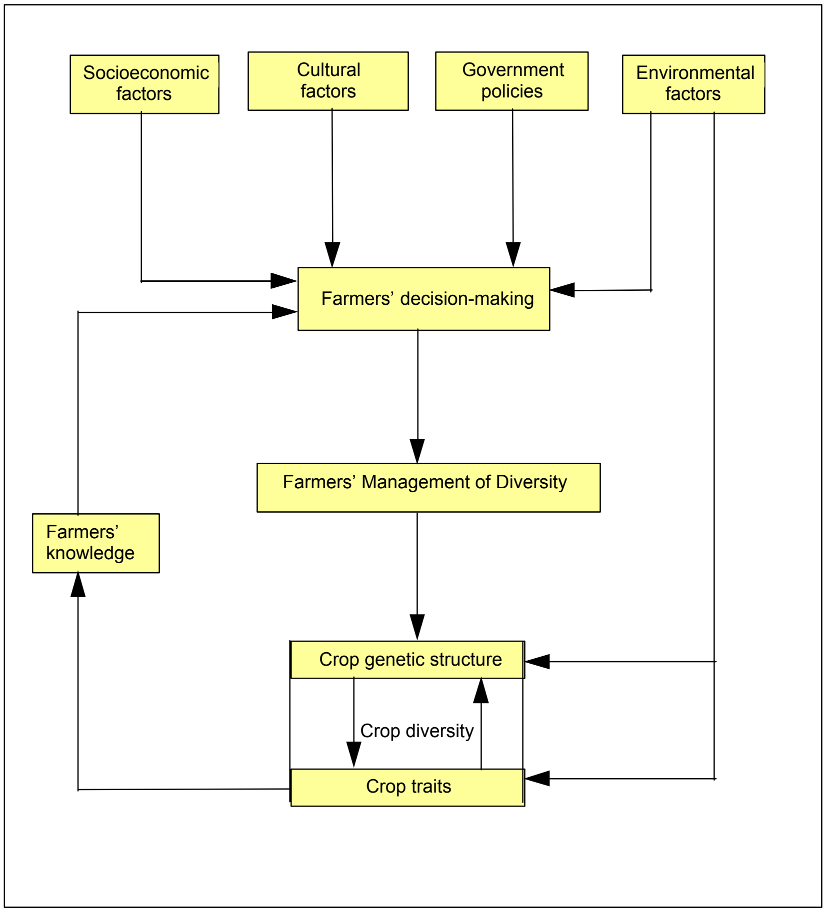
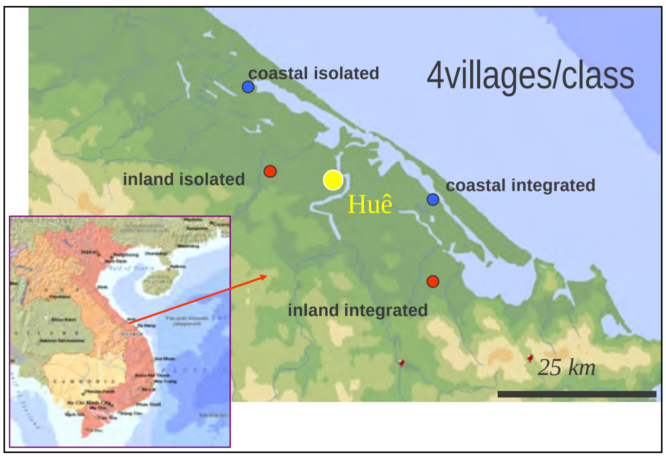


Figure 2. Study sites of the IRRI-coordinated on-farm conservation research project.

- Philippines

- Vietnam



- India

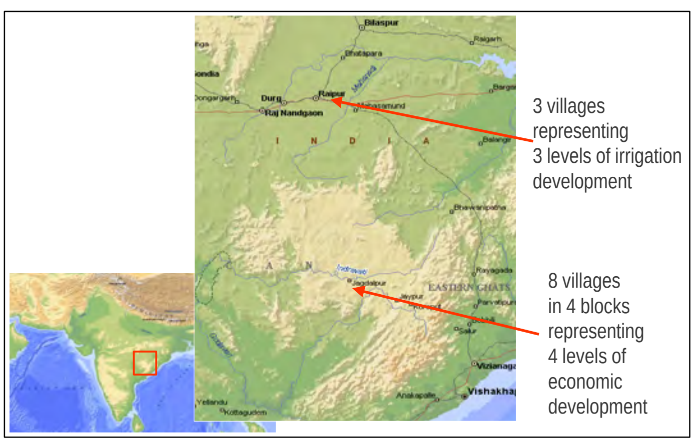


Figure 3. Relation between the number of villages on the Bastar Plateau (India) where varieties are grown and the number of farmers who grow them. Eight villages and 14 farmers were surveyed. Modern varieties tend to be locally-distributed (present in few villages) and rare (grown by few farmers). Widespread traditional varieties are frequent. Locally-distributed traditional varieties can be frequent or rare

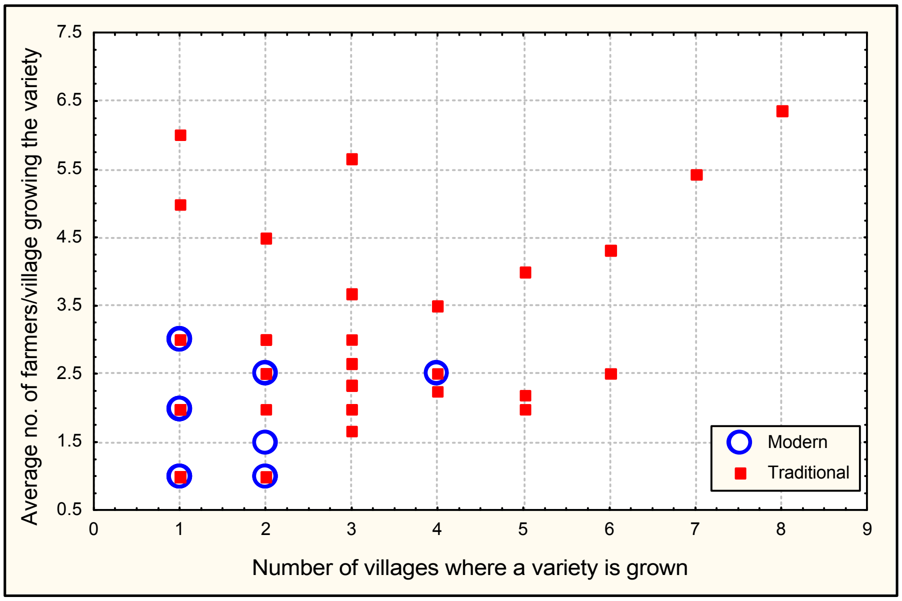
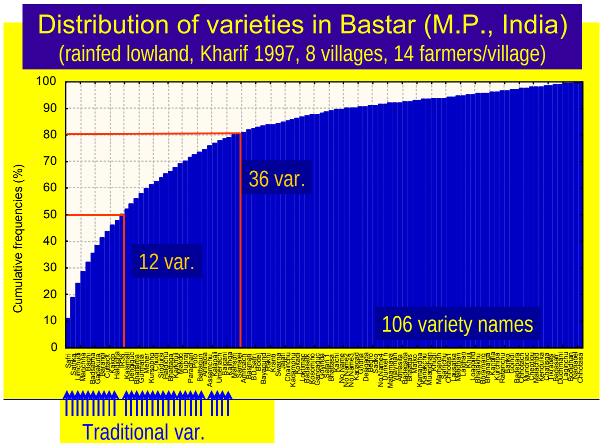
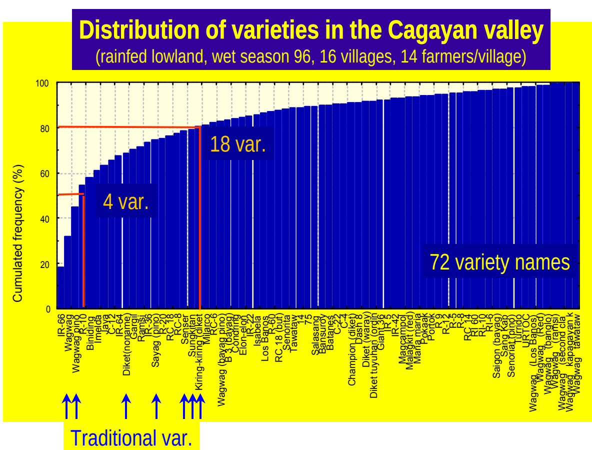


Figure 4. Cumulative frequencies of variety names in the study sites of the three study countries. Varieties are ranked from the most to the least frequent. The graphs show the number of varieties accounting for 50% and 80% of the total number of occurrences (sum of the number of times each variety occurs). Only those traditional varieties contributing to the 80% of the occurrences are indicated.





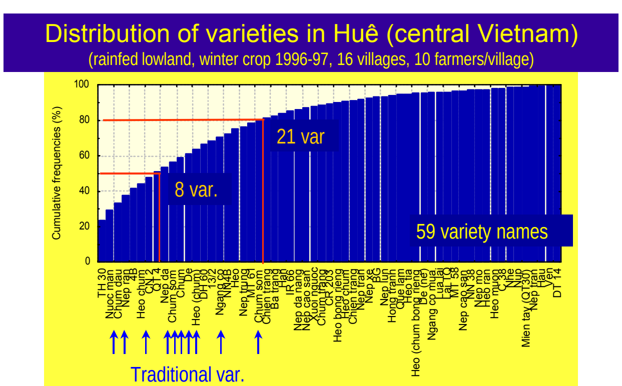


Figure 5. Number of unique microsatellite alleles contributed by four classes of varieties in central Vietnam: traditional (TV)/ modern (MV) varieties, summer (dry)/winter (wet) season. The numbers were computed in three possible cases: all the varieties are maintained (current situation), 10 most frequent varieties maintained in each category, 5 most frequent varieties maintained.

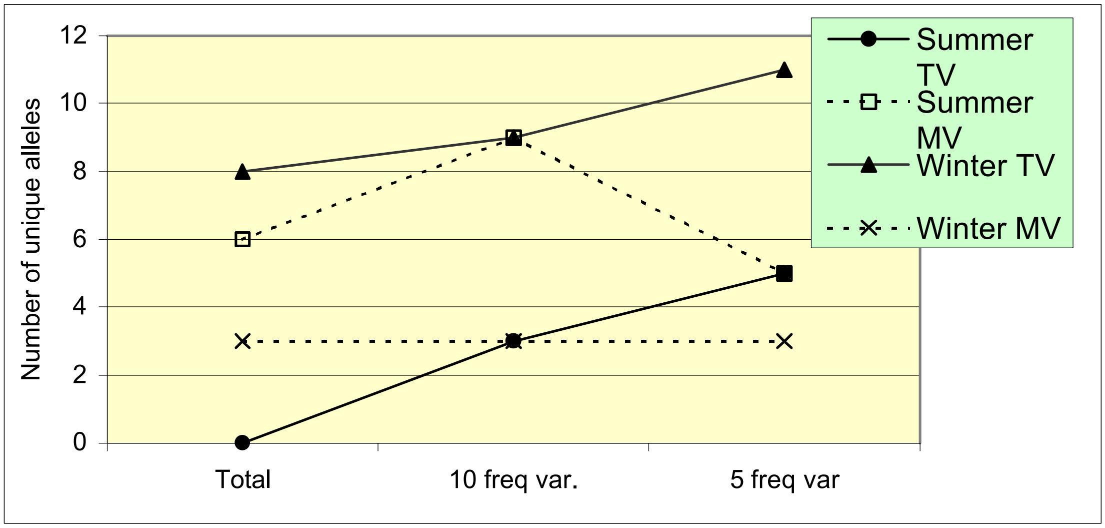


Figure 6. Cultural perception of the most frequent varieties in the Cagayan Valley, Philippines. The primary methodology used for creating variety classes was successive pile-sorting, where each informant was asked to sort a set of items into smaller and smaller piles until each pile was a single item. Farmers were asked to give the reasons for splitting at every stage. From pile-sorting a similarity matrix was produced. Varieties were then plotted using multidimensional scaling.

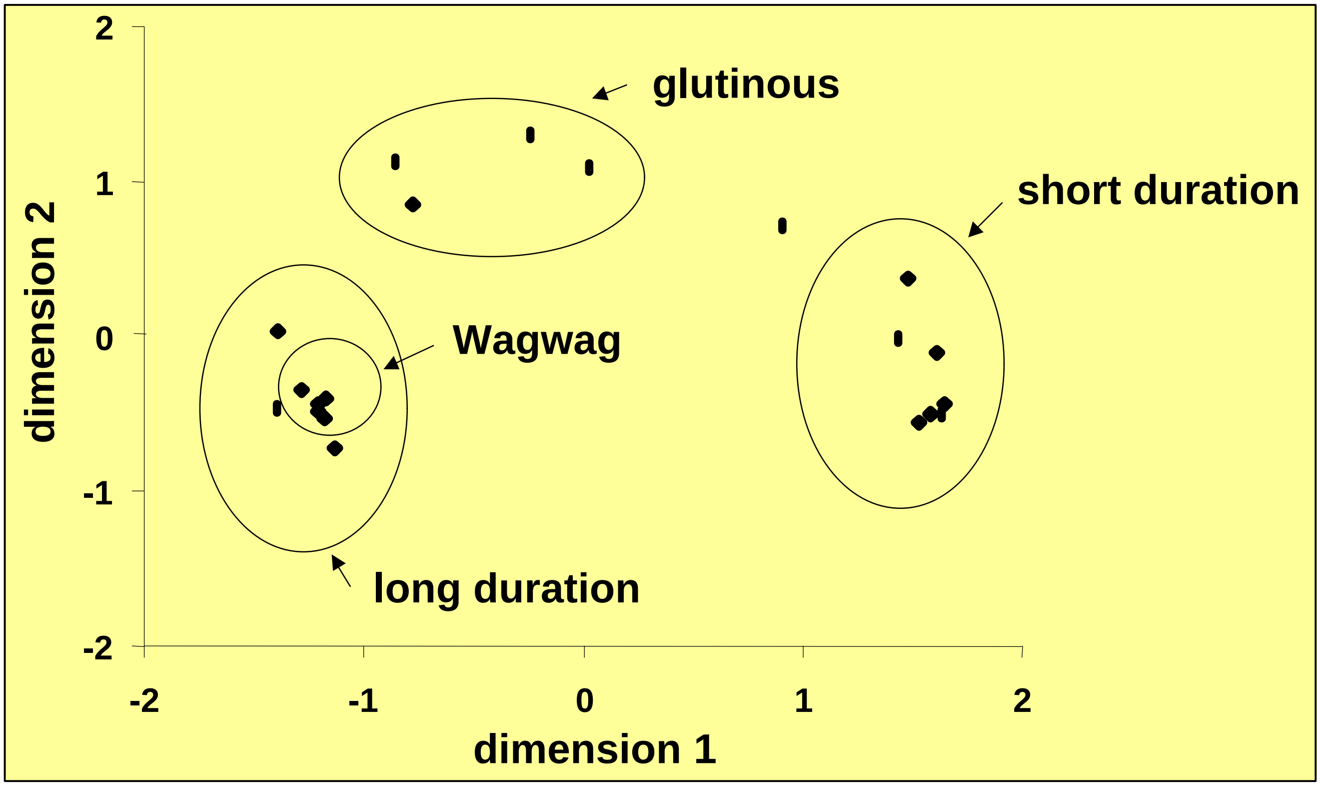


Figure 7. Correspondence analysis of the microsatellite polymorphism of 149 accessions from the Cagayan Valley (15 primers).

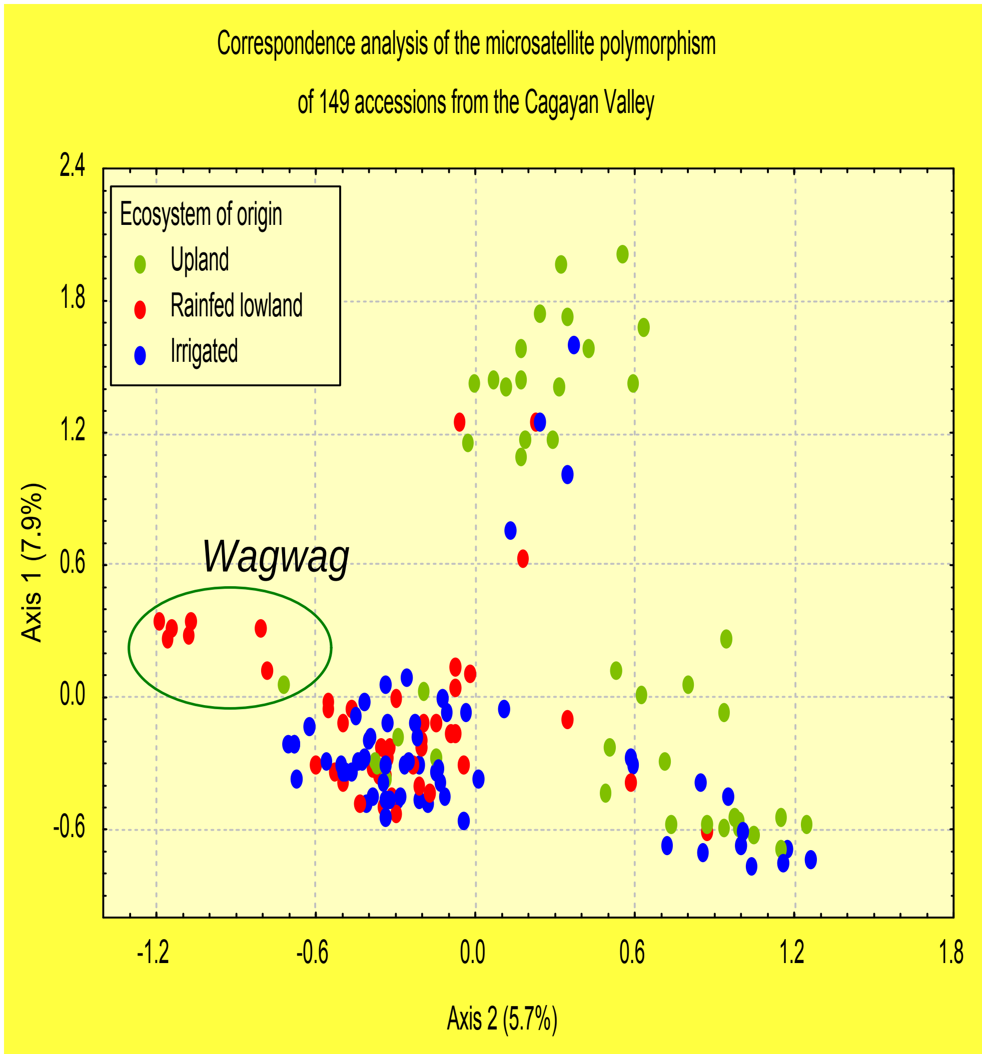


Figure 8. Comparison of the genetic diversity at each of 18 microsatellite for two sets of accessions in the Cagayan Valley: all varieties present in Cagayan and non-Wagwag varieties.

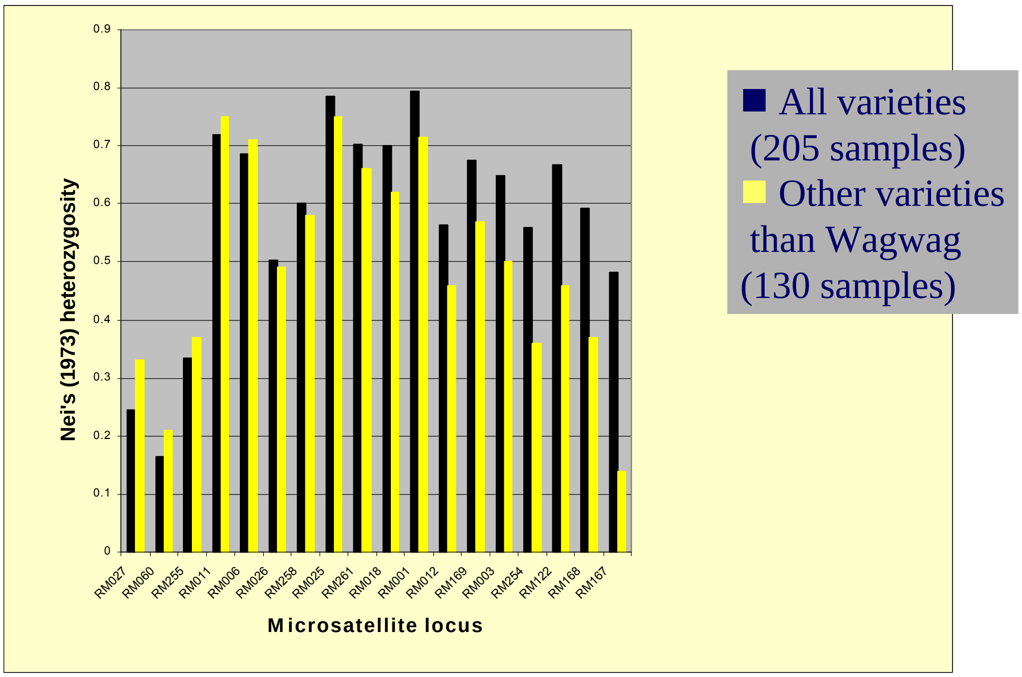


Figure 9. Relation between the landholding size of farming households and the number of varieties they maintain in Bastar. The landholding size is a limiting factor to the number of varieties kept by a farmer. The number of varieties is highly variable within a class of landholding. A trend is observed towards a reduced number of varieties for big farmers.

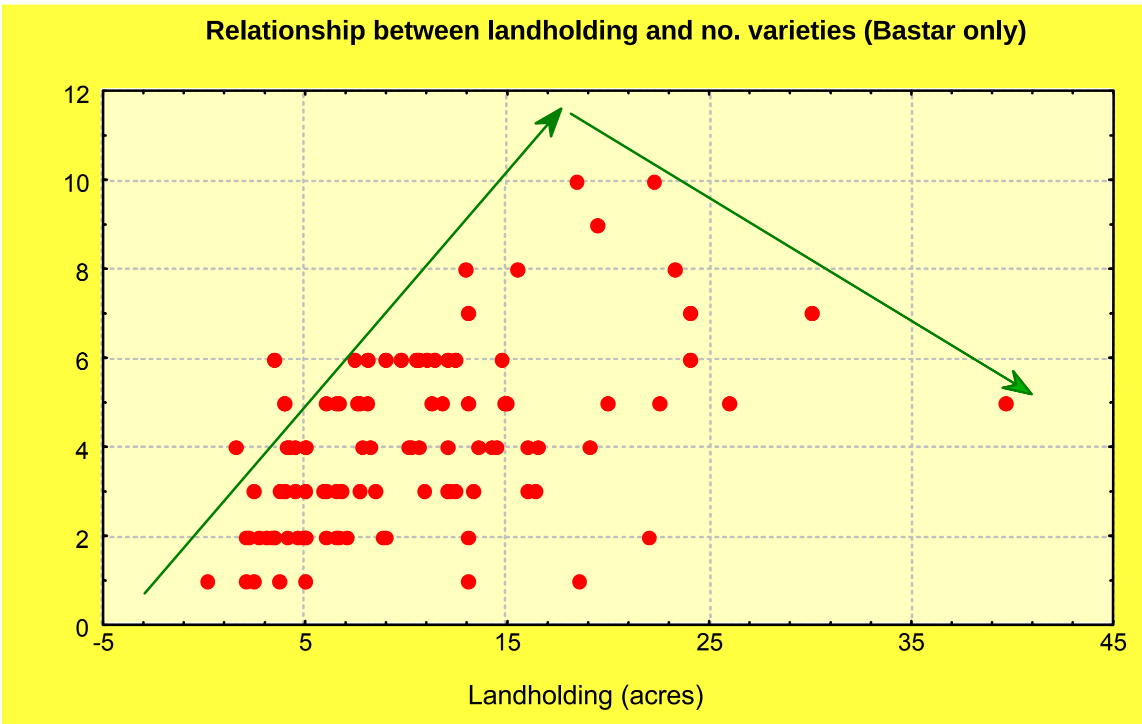


Figure 10. Classification of plot situations (a combination of slope, soil and water conditions) in Madhya Pradesh.

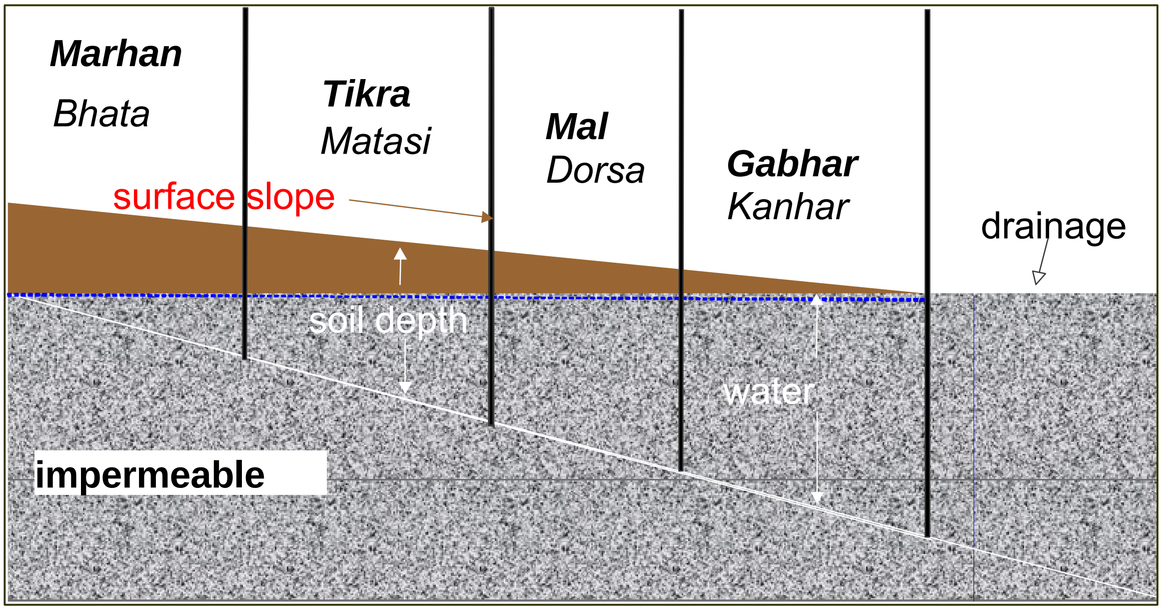


Figure 11. Distribution of traditional and modern varieties by ecosystem in central Vietnam. Results based on the survey of 8 villages per ecosystem and 10 households per village.

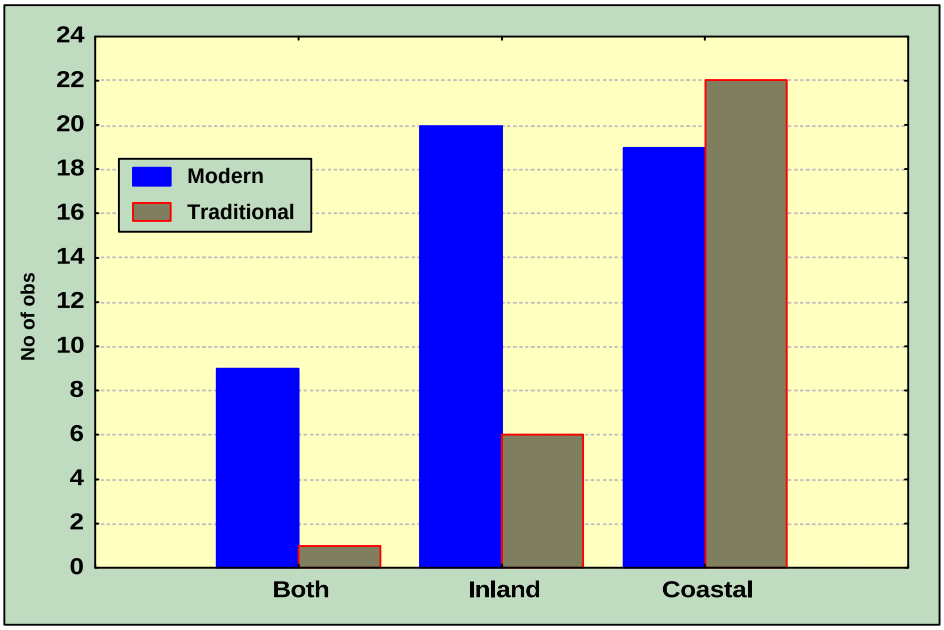
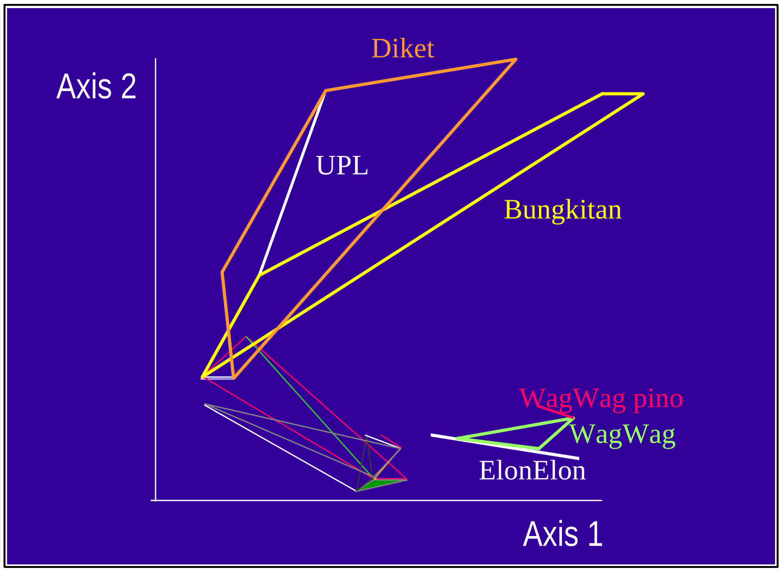


Figure 12. Analysis of the within-name diversity of varieties from the Cagayan valley. The analysis of the isozyme polymorphism (14 loci) revealed that not all accessions of varieties having he same name were identical. On this graph, all distinct genotypes observed or a given name were linked to each other. Figure 12a gives the overall view of the plan defined by the first two axes, while Figure 12b presents a detailed view of this plan.

12a



12b

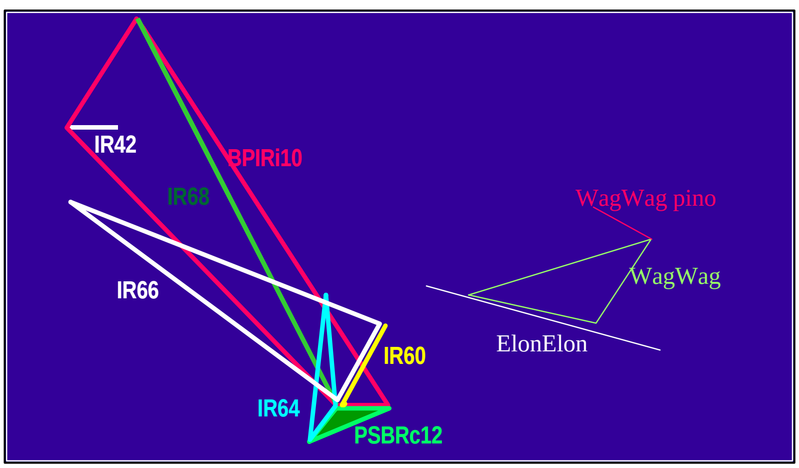


Figure 13. Cluster analysis of 25 accessions of Sathka (polymorphism observed at 7 microsatellite loci, UPGMA), a popular variety from the Bastar plateau. Accessions are represented by their village of origin.

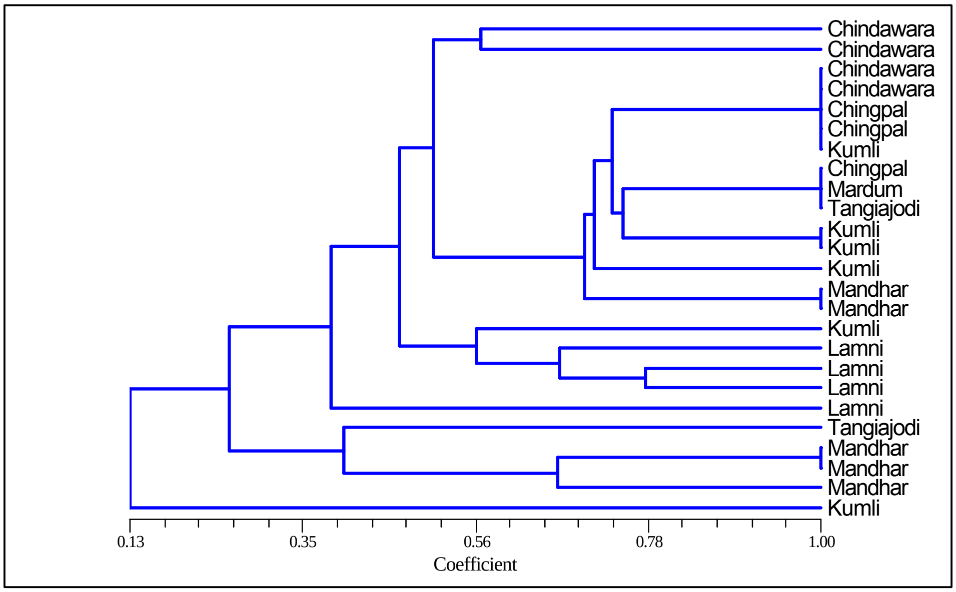
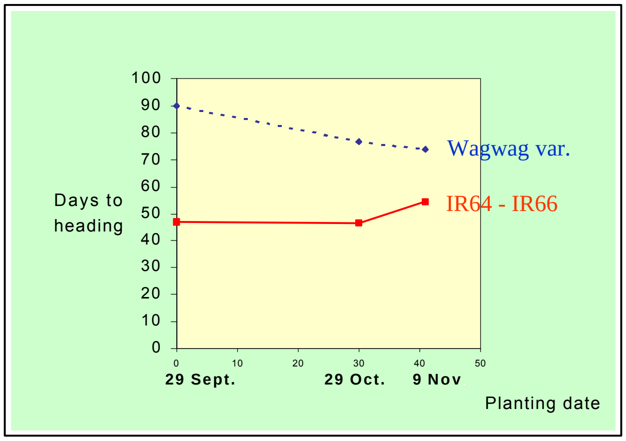


Figure 14. Effect of late planting on heading date (a) and yield (b) of long duration photosensitive varieties (Wagwag) and short duration varieties (IRRI varieties). The trial was conducted at IRRI Los Baños in 1998. The earliest date of planting in this trial was equivalent to the latest date of planting by Cagayan farmers.



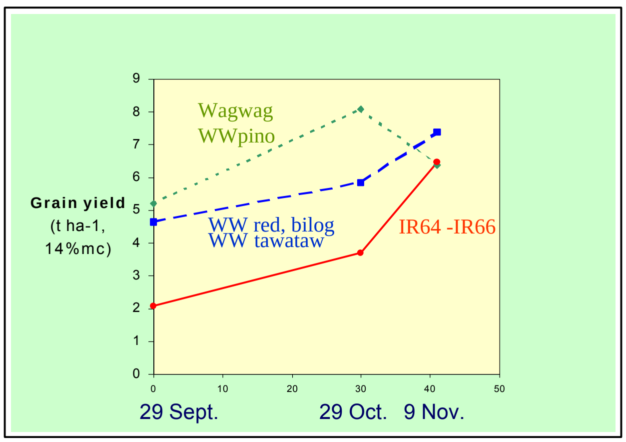


Figure 15. Rice cropping patterns in the rainfed-lowland ecosystem in the Cagayan Valley.
Top to bottom:

- Current cropping pattern for long duration traditional varieties. Only one crop per year is possible.
- Current cropping pattern for modern short duration varieties. Two crops per year are possible if irrigation is available during the dry season.
- Proposed double cropping pattern. By delaying the planting date of the long duration traditional varieties, it becomes possible to grow a first crop with a short duration variety with limited irrigation supply.

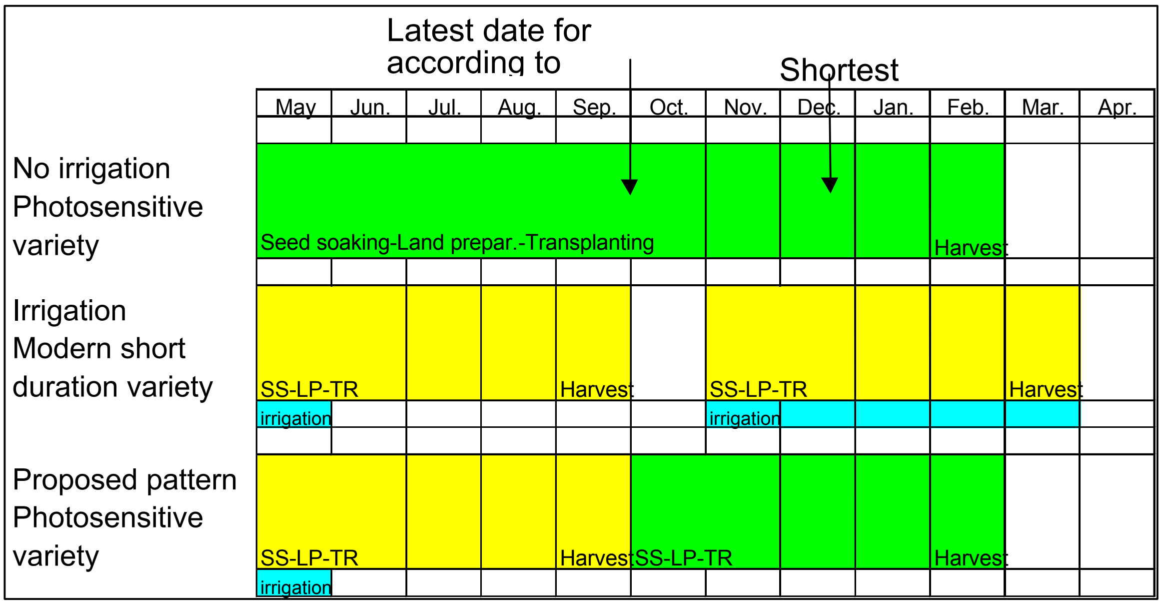


Figure 16. Changes in the proportion of cultivated modern and traditional varieties, in selected municipalities in Cagayan Province, 1996-1998.

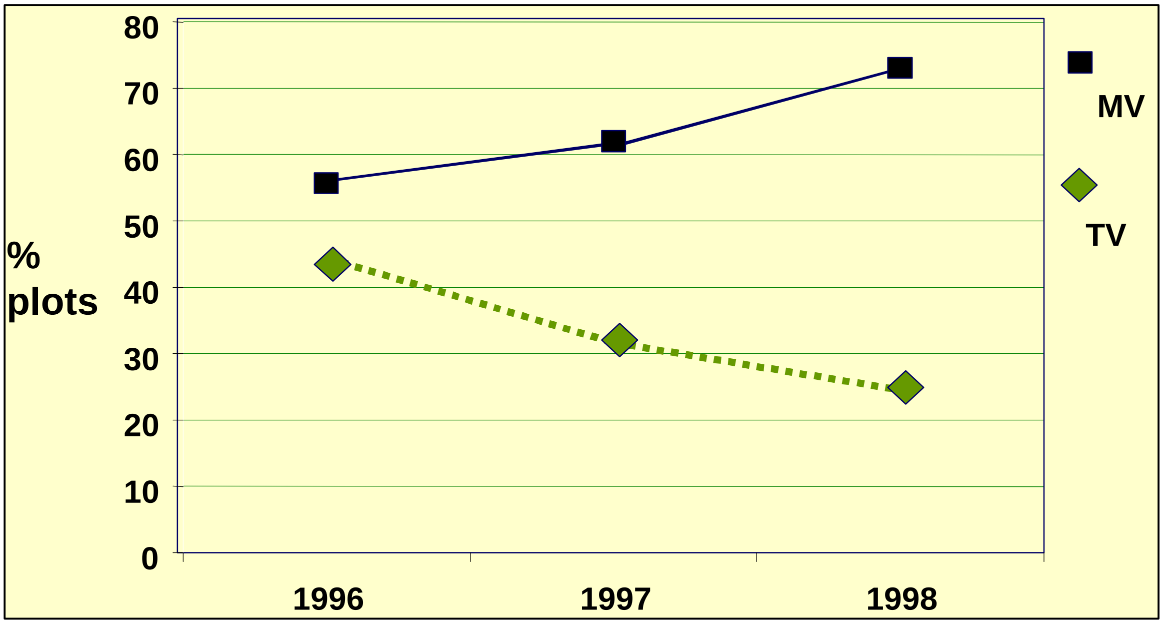


Fig. 17. Expenditures by major budget and project component categories, November 1993- May 2000. (Total budget = US$ 3,286,000).

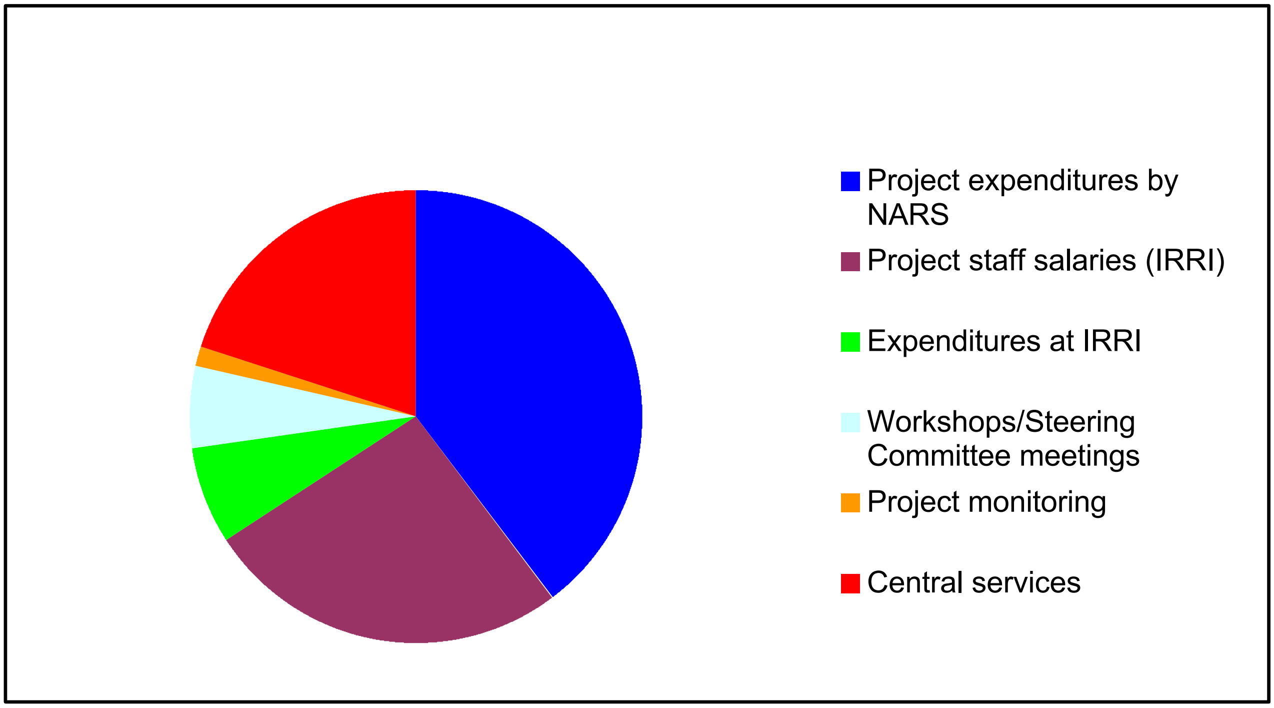


Fig. 18. Expenditures by country or institute for germplasm collection and strengthening capacity (Components I and III).

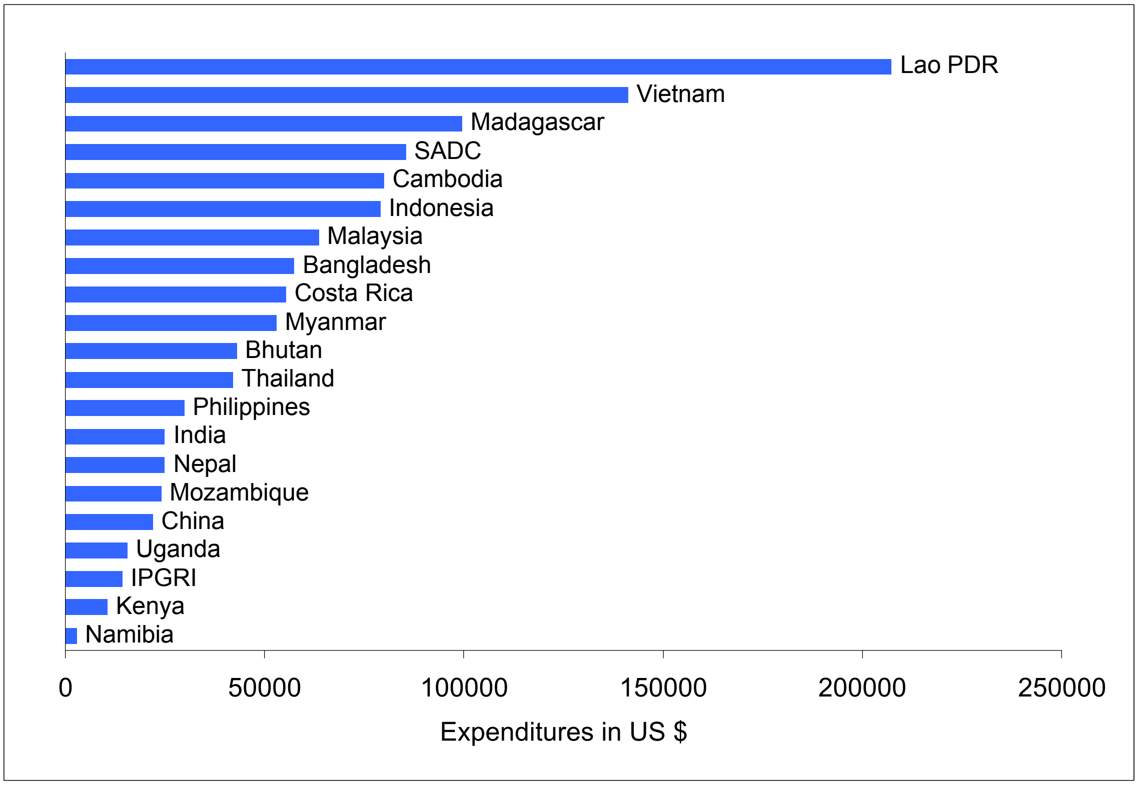


Fig. 19. Expenditures for on-farm conservation (Component II) by IRRI and its NARS partners.