Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity on-farm

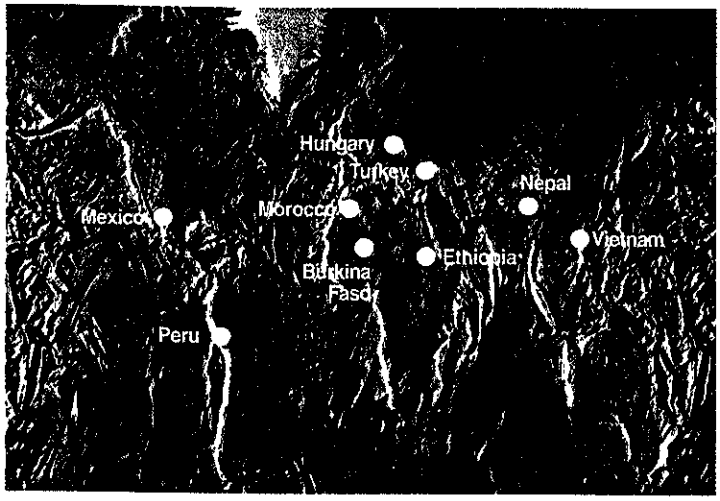
Introduction

***In situ* conservation is concerned with maintaining species' populations in the natural habitats where they occur, whether as uncultivated plant communities or in farmers' fields as part of existing agro-ecosystems. *In situ* conservation of crop plants involves the conservation on-farm of local crop cultivars (or landraces) with the active participation of farmers. The current project status is summarized here.**

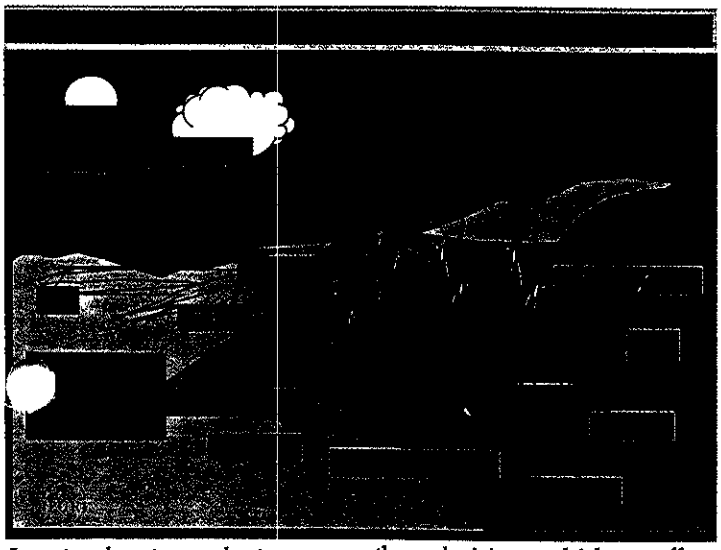
Factors shaping the genetic diversity of crops

Crop diversity in agricultural systems, in addition to being affected by population structure (e.g. mutation rates, migration, population size, isolation, breeding systems and genetic drift) and natural selection from the surrounding environment (e.g. soil type, climate, disease, competition), is affected by human selection and management. Crop genetic resources are passed from generation to generation of farmers and are subject to different natural and human selection pressures. Environmental, biological, cultural and socioeconomic factors influence a farmer's decision to select or maintain a particular crop cultivar at any given time.

Farmers, in turn, make decisions in planting, managing, harvesting and processing their crops that affect the genetic diversity of the crop populations.



Over time a farmer may modify the genetic structure of a population by selecting for plants with preferred agromorphological characteristics. He or she may influence the survival of certain genotypes by choosing a particular farm management practice or by planting a crop population in a site with a particular micro-environment. Farmers make decisions on how much of each crop variety to plant each year, the percentage of seed or germplasm to save from their own stock and the percentage to buy or exchange from other sources. Each of these decisions, which can affect the genetic diversity of cultivars, is linked to a complex set of en-



In natural systems, plant diversity is affected by population structure and by the

Maintaining crop genetic diversity

There are growing pressures on small farmers who maintain significant amounts of crop genetic diversity in the form of local cultivars. Increased population, poverty, land degradation, environmental change and the introduction of modern crop varieties have contributed to the erosion of genetic resources in crops. In recent decades, agricultural scientists have responded to the threat of genetic erosion by developing a worldwide network of genebanks and botanical gardens for conserving the available useful genetic resources *ex situ*. While this has been the main strategy against the loss of genetic diversity in our crops, facilities are unlikely to accommodate the full range of useful diversity in economically useful plant species. In addition, these facilities do not conserve the dynamic processes of crop evolution and farmer's knowledge of crop selection, management and maintenance inherent in the development of local cultivars. Nor can they ensure the continued access and use of these resources by farmers.

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Directorate General for International Cooperation (DGIS), the Netherlands

International Development Research Centre (IDRC), Canada

Bundesministerium für Wirtschaftliche Zusammenarbeit (BMZ) / Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Germany

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processes of evolution and adaptation of crops to their environments, (2) conserve diversity at all levels – the ecosystem, species and the genetic diversity within species, (3) improve the livelihood for resource-poor farmers, (4) maintain or increase control and access of farmers over their genetic resources, and (5) integrate farmers into the national plant genetic resources system for conservation.

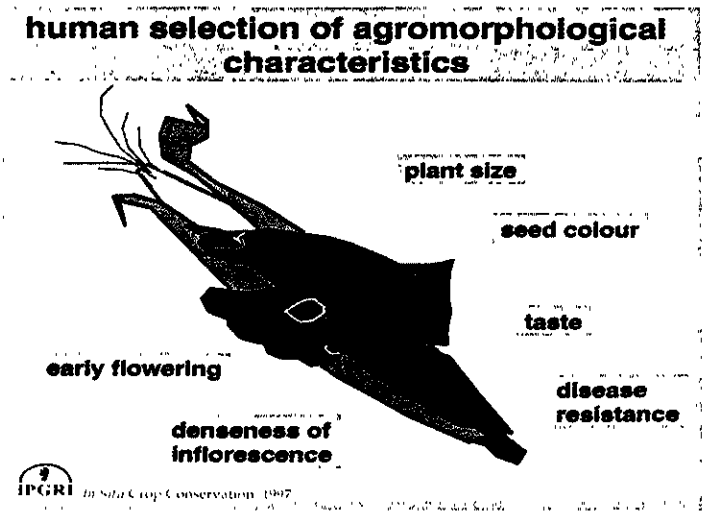
Diversity for use and development

The International Plant Genetic Resources Institute (IPGRI) is committed to advancing the conservation and use of plant genetic resources for the benefit of current and future generations. Effective management and conservation of genetic resources on-farm takes place where the resources are valued and used to meet the needs of local communities and contribute to development. In order to be maintained by farmers, genetic resources must be:

- competitive with other options a farmer might have, and
- contribute to the security and possible increase in a farmer's income.

Value may be added to crop resources in two main ways: (1) the material itself may be improved or (2) the demand for the material or some derived product may be increased. The first option is to seek improved quality, disease resistance, yield, taste or other preferred characteristics, through participatory plant breeding. The second option includes adding value to crop resources by better processing, storage and marketing, to increase the value and benefit that farmers receive from the use of the genetic resources.

Community-based organizations, extension workers and NGOs who work closely with farmers have an important role to play in identifying managed genetic resources. Such organizations can also recommend strategies which support farmer management practices that increase the amount of genetic diversity and identify counterincentives to the use of diversity, e.g. policies and market constraints. Community-based organizations and NGOs also assist the formation of farmer cooperatives and community seed banks to maximize returns to the farmers themselves.



Crop diversity in agricultural systems, in addition to being affected by population structure and natural selection from the surrounding environment, is affected by human selection of agromorphological characteristics.

IPGRI and national partners: the development of a global project

IPGRI's mission is to encourage, support and engage in activities to strengthen the conservation and use of plant genetic resources with special emphasis on developing countries. IPGRI works in partnerships with national programmes to undertake research and training, and provides scientific and technical advice and information.

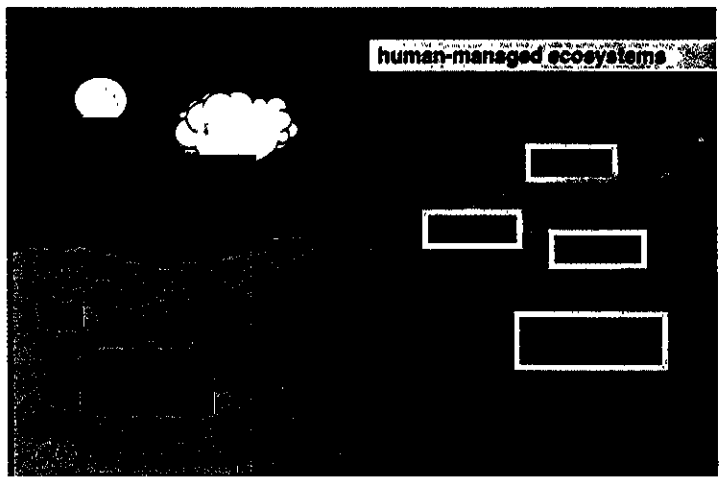
A major challenge for *in situ* conservation is the development of the knowledge needed in national programmes to determine where, when and how *in situ* conservation will be effective. In response to this challenge, **IPGRI**, together with **National Partners** in nine countries, formulated a global project to strengthen the scientific basis of *in situ* conservation of agricultural biodiversity. the project are **Burkina Faso, Ethiopia, Hungary, Mexico, Morocco, Nepal, Peru, Turkey** and **Vietnam**. These nine partner countries were included because each was within a region of primary diversity for crop genetic resources with worldwide importance. Each has traditional farming communities which maintain plant genetic resources. The countries all have national programmes organised to conserve crop resources, which include *ex situ* conservation facilities, and all indicate a strong interest in developing a national capacity to support *in situ* conservation. In each country, strengthening the relations of formal institutions with farmers and local-level institutions to promote on-farm conservation is a major concern.

Major objectives, hypotheses and preliminary activities for the project were decided

Human selection and management also include choices on what farming management practice to use, and where or in which micro-environment to plant. These management practices in turn will affect the genetic structure of the local cultivar.

Outputs expected for the project:

- Measures of the extent and distribution of the genetic diversity of selected crops over space and time
- A dataset linking farmer decision-making on the selection and maintenance of local cultivars with measurable indices of genetic diversity
- Identification of key or limiting factors (environmental, biological, cultural and socioeconomic)
- Descriptions of farmers' access and use of formal and informal seed supply systems
- Key indicators and measurements of the effect of increasing population pressures, land degradation and environmental change on the maintenance of on-farm diversity
- Information on the effect of market development (access to market, off-farm income, availability of credit to male



and female farmers) on the maintenance of on-farm diversity

- Recommendations for national economic and agricultural policy to the maintenance of on-farm diversity
- Trained male and female personnel in short courses in plant population genetics and ecology, biogeography, conservation biology, economics and anthropology
- Linked biological and social science programmes in institutes and universities
- Guidelines for research and practice in *in situ* conservation
- Standardized terms/definitions and common research protocols for *in situ* conservation for the nine participating countries
- Gender awareness incorporated in national *in situ* conservation programmes
- Increased number of women in management and decision-making roles and in training courses
- Communication networks between participating countries
- Decentralized breeding and selection techniques that enhance or maintain on-farm genetic diversity
- Improved local cultivars combining substantial genetic diversity with enhanced performance
- Male and female farmers and project personnel trained in decentralized breeding
- Strengthened community institutions for biodiversity management
- Improved links between formal and informal institutions and farmers
- Gender awareness incorporated in community and locally based *in situ* conservation programmes
- Information bases, for farmer use, on the characteristics and value of local varieties.

upon by IPGRI and National Partners at the First Participants Meeting held in Rome in July 1995. The three main objectives of the project are:

- to support the development of a framework of knowledge on farmer decision-making processes that influence *in situ* conservation of agricultural biodiversity
- to strengthen national institutions for the planning and implementation of conservation programmes for agricultural biodiversity,
- to broaden the use of agricultural biodiversity and the participation in its conservation by farming communities and other groups.

To achieve these objectives, three main strategies were agreed upon:

(1) multidisciplinary work in the areas of population genetics, ecology, agronomy and social sciences carried out by multi-institutional teams from formal institutions and community-based organizations to determine and understand the situations in which local cultivars are maintained by farmers,

(2) to identify the key factors which affect farmer decisions to maintain local cultivars,

(3) to understand how farmer decision-making affects the amount of genetic variation within crop populations over time, and

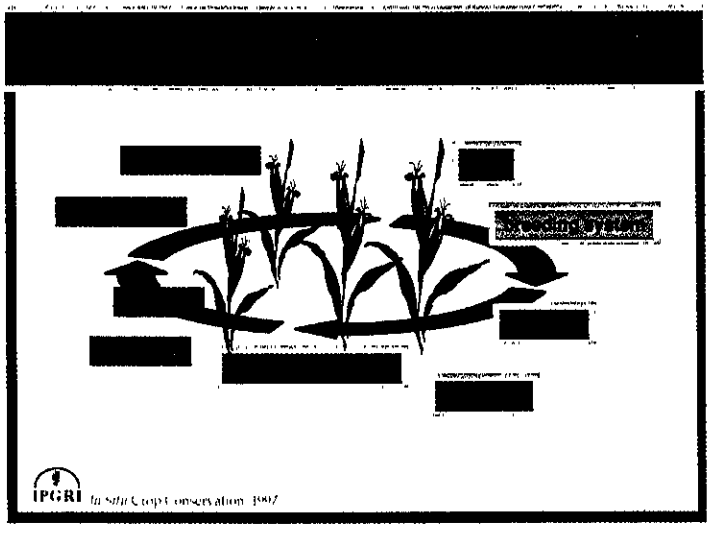
(4) to find ways to assist the continued selection of local cultivars or cultivars that conserve local germplasm.

In 1997, national partners, technical experts and IPGRI staff met to discuss and agree on information needed and methodologies to be used to understand the effects of farmer decision-making, agro-ecosystems and population structure and breeding systems on the genetic diversity of local cultivar population over time. The participants decided to collect and analyze information, data and farmer perceptions by gender, age and ethnic group in six main areas:

- socioeconomic, cultural and biological influences on farmer decision-making
- farmer selection of agromorphological characters
- population structure of local cultivars, including population size, isolation and geneflow between and within cultivars and crop wild relatives
- environmental selection by agro-ecosystems, including natural factors (e.g. soil, precipitation, temperature, disease, etc.) and managed factors (fertilizer application, irrigation, weeding, harvesting practices, etc.)
- seed/germplasm supply systems, and
- adding value through participatory plant breeding, market, non-market and consumer incentives and agricultural policy.

The basic sampling units decided for the above six areas are the farmer's household, the farmers' named crop variety, the farmers' field and the farmers' seed sample. These units will then be aggregated from household to village to community, from named crop variety of one farmer to the populations of the named variety in a village, and to populations of the variety across the landscape.

Within the global project the partners emphasize the representation of gender, age and ethnic groups at all levels, from decision-making to data collecting. The project strategy is participatory and relies on learning approaches rather than the development of specific models. The concern is to understand what is happening rather than to prescribe abstract solutions.



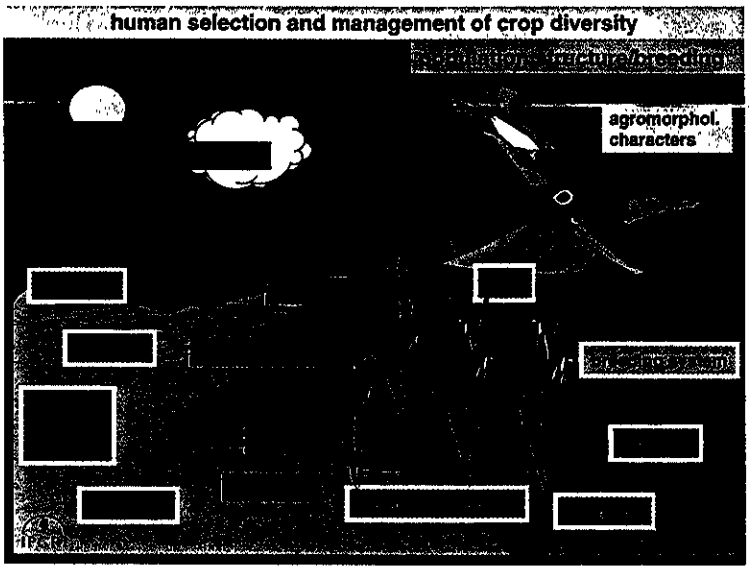
Farmer decision-making can also affect the population structure of the local cultivar population in the farmer's field. Farmers make decisions on the size of the population to plant (field size), the distance between populations/fields, the amount of seeds to save from their own crop or to use from other farmers (migration) and the breeding system to use. These decisions affect the genetic diversity of the cultivars.

(2) community participatory breeding and agronomic work, including community and locally based conservation activities involving market development, non-market incentives, and community-based training that will support sustainable agriculture, and

(3) international coordination and scientific synthesis to create a global framework for supporting *in situ* conservation by farmers.

As a result of the 1995 meeting, the national partners formulated the following key research questions:

Finally, the *in situ* conservation project is not aimed at dissuading farmers from adopting new crop varieties that are more productive and increase incomes. Rather, the project will contribute to a better understanding and appreciation of, and add value to the locally developed genetic resources maintained by farmers and will help to integrate on-farm conservation practices into the national PGR system.



Crop diversity in agricultural system is influenced by the natural and human-managed environment, by the population structure and the management of this structure by farmers, and by the selection of agro-morphological characteristics of the cultivar.

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Burkina Faso is a land-locked country of km² 274 000, located in the centre of the Niger river loop in West Africa. Burkina Faso is divided into three main agro-ecological zones: the Sahelian zone in the centre and centre-north, the Soudano-Sahelian zone to the west, and the Soudanian zone to the southeast. Research sites for the on-farm conservation project have been chosen from each of these zones. Selection of sites was also based on the presence of crop diversity, the soil types in the areas, and the importance of landraces in the area. Important crops identified for study in the project include sorghum, cowpea, pearl millet, okra and *Solenostomum*.

Ethiopia is recognized as a primary centre of diversity for wheat, sorghum, barley and coffee as well as for such crops of regional importance as tef and enset. The six sites chosen for the initial activities of this project are the same sites that have been targeted for the GEF-supported project for *in situ* conservation of Ethiopia's local landraces. These sites are Eastern Tigrai, Tegulet in Northern Shewa, Bonga in Keffa, Ada in eastern Shewa, Kalu in Wollo and Ginir in Bale. In each region, localities were selected with the assistance of the district agricultural officers, based on the extent of genetic erosion due to drought, intensive use of improved varieties and the extent of genetic diversity.

The lead institute responsible for the implementation of the global *in situ* (on-farm) conservation project in **Hungary** is the Institute of Agro-botany. Three sites have been chosen for the implementation of this project: Körös, Nyirség and Zselicég. The sites were selected based on elevation, climate (including humidity), soils and the cropping system. Crops selected for the project include vetch, curcurbits, paprika, rye and oats. The selection of crops was based on the presence of high diversity in cultivated traditional landraces.

The crops selected for conservation in the *in situ* project in **Mexico** are those of the "milpa" system, the traditional Maya system of annual crops grown in association. These include maize, lima bean, squash, chilli peppers and peanut. The site for project implementation is located in the north-centre of the Yucatan peninsula, in an area where almost 50 000 families still grow "milpa" (maize, beans, squash and other crops) with slash and burn agriculture. Crops were selected because of the broad range of genetic diversity still found in Yucatan landraces, which is now threatened by increased production costs, technological change, loss of labour and a shorter fallow period. The area has an altitude of 20-25 m asl, a warm, subhumid climate and an average annual temperature of above 25°C. The rainy season is from June to October, with a brief dry period in August. The majority of the soils are shallow, stony and calcareous.

Morocco is a centre of diversity for wheat, barley, faba bean and alfalfa. Three agro-ecological zones have been selected for the *in situ* project: (1) Demnate/Tanante region, in province of Azilal, Direction Provinciale del'Agricuture (DPA) in the high Atlas, (2) Valley of Ziz-Tafilalte, Errachidia Office Regional de Mise en Valeur Agricole (ORMVA) in the oasis area, and (3) Taza DPA/Chefchaouen DPA in the Rif and Pre-Rif Mountain area. Priority crops to be included for study in this project are barley, durum wheat, faba bean, alfalfa and bread wheat. These crops were selected on the basis of their economic importance; the appreciation of landraces by local farmers: adaptation for abiotic stresses, grain and straw quality, special uses in preparing local dishes; the availability of scientific data showing the existence of genetic diversity of these crops, and the extent of threat of their diversity by the extension of new released cultivars

The Kingdom of **Nepal** contains a rich centre of crop genetic diversity because of agro-ecological variations, antiquity of agriculture and traditional farming system. Three sites have been selected on the basis of the richness of agrobiodiversity, the status of on-farm conservation by farmers, and the physical and technical capacities available in the regions. Three physiographic regions of Nepal represent high-, middle- and low-altitude crop production ecosystems of Nepal. Both *bari* (upland) and *khet* (lowland) land-use systems will be included when sites are selected. Crops that are associated with rice and maize farming systems in all three ecosites will be considered. Crops will be prioritized by the community involved. The major crop focus will be on rice, finger millet, indigenous vegetables and neglected crops (buckwheat, foxtail millet, blackgram, horsegram, niger and sesame).

The Andean highlands in **Peru** are a centre of diversity for roots and tubers including the globally important potato, and also for locally important grain crops such as quinoa. Farmers have local knowledge about the sustainable utilization of their resources. The project is based on the utilization of a cultural approach to maintain biodiversity *in situ*. Crops being considered are potato and quinoa in the high plateau areas of Puno at 3900 m asl and Cusco at 3600 m asl.

Turkey is a major part of the West Asia Centre of crop domestication, evolution and diversity. The transitional zone adjacent to the Aegean and central Anatolian region has been selected as one site of research within the *in situ* project. This region has retained traditional farming methods to a much higher degree than the intensively cultivated (irrigated) coastal zone or the Anatolian plateau. In this area, the farm population is fully integrated into the national economy and culture of Turkey. This region includes three agro-climatic zones, including valley bottom land, where farmers often grow both modern and local cultivars. Possible crops selected for the project include chickpeas and durum wheat.

Vietnam is an important centre of diversity for crops such as rice and taro. Initial site surveys are being undertaken in the Red river delta (Nghia hung, Nho quan and Hai hau districts), Central Vietnam (Nghia dan, Quynh lun and Quynh chan districts) and South Vietnam (Dalat municipality and Ninh son district) for possible site location. A number of crops have also been targeted for study in this project. These include mung bean, soy bean, rice and taro. Existence of crop diversity within the species was one criterion for selection of crops.