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Agrobiodiversity – plant genetic resources

At a time when a growing world population needs to be fed on limited resources in a changing climate, the conservation and sustainable use of agricultural biological diversity gains utmost importance. Agrobiodiversity plays a crucial role in food security and nutrition, as well as in the provision of environmental services and livelihoods. It is critical to the sustainability, resilience and adaptability of agricultural production systems. To promote awareness and share knowledge on conservation and the sustainable use of agrobiodiversity, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), has published this series of agrobiodiversity factsheets.

The present factsheet gives attention to plant genetic resources as an important part of agrobiodiversity. (Note: One of the other factsheets deals with animal genetic resources). It explains the importance of genetic diversity in our food crops. After introducing relevant key events and institutions as well as *in situ* and *ex situ* conservation, attention is given to the potentials which exist in neglected and underutilized species, crop wild relatives and wild plants for food and trade, but also to threats for agrobiodiversity through invasive alien species. Besides conservation of plant genetic resources, their further development needs to be assured. Focus is given to local plant breeding and seed distribution, for example, through participatory plant breeding, seed fairs, and community seed banks. Finally, the paper lists key principles for conserving plant genetic resources for food and agriculture.

What is agrobiodiversity?

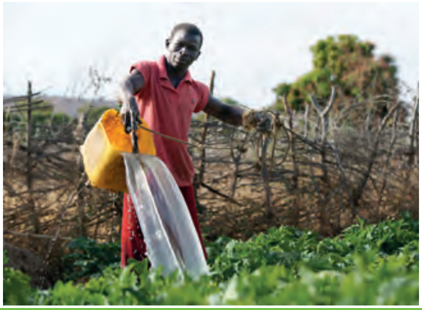
Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem. Agrobiodiversity is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers and herders. It has developed over millennia, as a result of both natural selection and human interventions.

Plants for food and agriculture and their genetic diversity

Of the 250,000 globally identified plant species, about 7,000 have historically been used in human diets. At present, however, only about 30 crops form the basis of world's agriculture and just three species – maize, rice and wheat – supply more than half the world's daily calories. Within each plant species, a high number of varieties and great genetic diversity may be found. Unlike modern improved varieties (cultivated varieties, abbreviated 'cultivars'), traditional varieties (also known as farmers' varieties or landraces) are genetically much more variable.

FAO estimates that more than 75 % of global crop diversity has disappeared irrevocably over the 20th century. Not only has the diversity of species reduced, but also the diversity of varieties within the species. With the advent of modern agriculture, untold numbers of locally adapted crop varieties were replaced by genetically uniform, high-yielding modern varieties. In South Korea, for example, 74 % of the most common crop varieties in 1985 had been replaced by 1993. Farmers in India once grew 30,000 rice varieties – today, 75 % of India's rice crop comes from just ten varieties. In Mexico, only 20 % of the maize varieties known in 1930 are still in use.

Many risks – including crop failure and commodity price variability – go along with relying on a limited number of


Photos, l.t.r.: © Feng Yingli; © GIZ; © Ute Grabowsky/photothek.net crops. The genetic diversity contained in traditional varieties and crop wild relatives but also in improved cultivars provides a crucial basis for food production; it has potential for the valorisation of products derived from agrobiodiversity and offers greater possibilities for adaptation and resilience in the face of climate change. All countries in the world depend and interdepend on plant genetic resources and there is a continuous need to conserve, exchange and transfer healthy genetic material, and to develop new material based on the traditional varieties. This is the foundation for sustainable agriculture and strong, dynamic agro-ecosystems. Plant diversity is also necessary for the delivery of ecosystem services such as pollination, pest-predator balances, carbon sequestration and water conservation.

One out of 6723

In Asia in the 1970s, a disease emerged that affected the productivity levels of rice: the rice grassy stunt virus (RGSV) and its carrier, the brown plant hopper, infested rice crops in much of Asia. The virus prevents the rice plant from producing flowers and grain. Asia was on the brink of catastrophe.

The International Rice Research Institute (IRRI) desperately began looking for a solution to the problem. IRRI maintains a seed bank of many thousands of types of rice, including recently developed hybrids and wild varieties. They used this resource to search for a variety that had a natural resistance to the disease. After screening 6,723 accessions of cultivated rice and several wild species of rice, one accession of *Oryza nivara* was found to be resistant, a wild rice species from Orissa, India (Note: An accession is a distinct, uniquely identifiable sample of seeds in a gene bank). The gene that carried the resistance to RGSV was immediately crossed into new varieties, which were then dispersed to replace the earlier IRRI rice cultivars.

Since then, the RGSV resistance gene has been incorporated into numerous cultivars developed at IRRI as well as by different national rice improvement programs. Today millions of farmers across Southeast Asia grow RGSV-resistant rice varieties originating from *Oryza nivara*. By crossing rice varieties with this wild relative, rice cultivation in Asia could be saved. This was only possible because economically useless wild rice had been preserved. For more information, see IRRI (2010) and www.cwrdiversity.org.

Genetically diverse plant populations and species-rich ecosystems have greater potential to adapt to climate change and develop resilience.

However, the increasing demands for food combined with socio-economic development efforts threatens the existence of traditional varieties and can lead to the destruction of natural habitats of wild species. This results in narrowing of the genetic base – 'genetic erosion' and 'genetic wipe-out'. To ensure food security, proper attention to manage plant genetic resources is necessary.

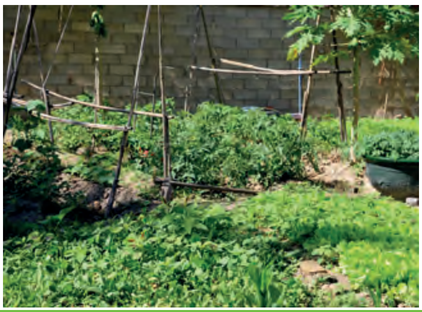
Global governance of plant genetic resources for food and agriculture

The domestication of plants started about 10,000 years ago, but only about 150 years ago, plant genetic resources began to be used in a more scientific manner. Thanks to advances in genetics following Darwin's theory of evolution, the discovery of Mendel's laws, and Vavilov's description of the centres of origin of cultivated plants, the value and potential of genetic diversity was discovered (see also seedmap.org). The Irish potato famine of 1846 dramatically demonstrated the need for genetic diversity in agriculture. In the 1960s and 1970s, the Green Revolution boosted productivity, but also contributed to the loss of genetic diversity. Only then, concerns regarding genetic erosion and vulnerability of our agricultural production systems led to scientific and institutional developments in plant genetic resources for food and agriculture.

Over time, different organizations have evolved with the mandate to advance the international agenda on plant genetic resources for food and agriculture. A key actor is the Food and Agriculture Organisation of the United Nations (FAO). Its Commission on Genetic Resources for Food and Agriculture (CGRFA) covers all five subsectors – plant, animal, aquatic and forest genetic resources as well as micro-organisms and invertebrates.

Bioversity International is the research-for-development organisation concentrating on plant agrobiodiversity of the Consultative Group for International Agricultural Research (CGIAR). Other CGIAR centres have crop gene banks under their custody. They generally represent the major repositories for germplasm of their mandate crops. For example: the world's major wheat (13 % of the total) and maize (8 % of the





Photo, l.t.r.: © Heinz-Josef Heile, © GIZ, © Li Qingsong total) collections are held at CIMMYT, that of rice (14 % of total) is at IRRI, and CIAT is responsible for the world's largest collections of beans (14 %) and cassava (17 %; FAO, 2010). Germany has made considerable financial contributions to develop these gene banks and support the maintenance of selected banks.

The Global Crop Diversity Trust is funding the world's most important agricultural gene banks, which is supported financially by the German government amongst others. The Trust maintains the ultimate failsafe for these seed collections in the Svalbard Global Seed Vault (see box page 4). Important steps and key events concerning plant genetic resources for food and agriculture are given in the timeline below. For further information, see also the GIZ factsheets (in the present text, GIZ factsheets, hyperlinked, are marked with ▸):

- *GIZ, 2015: Understanding agrobiodiversity*
- *GIZ, 2015: International agreements on agrobiodiversity*

In situ and *ex situ* conservation

There are two complementary responses to the loss of global crop diversity: *in situ* and *ex situ* ('on site' and 'off site') conservation. *In situ* conservation helps to guarantee the survival of a species in its natural habitat and allows it to adapt to a changing environment. *Ex situ* conservation preserves the genetic material artificially and prevents extinction.

In situ conservation

Home gardens – treasure troves of agrobiodiversity

In many countries, home gardens play a significant role for *in situ* conservation because they contain a great combination of trees, shrubs, vegetables, root crops, grasses and herbs that provide food, spices, medicines and construction materials. In home gardens of Vietnam, which are on average a quarter of a hectare, an overall total of 646 plant species and varieties were identified. These systems do not only secure food and income, but also often have important nutritional and cultural value. Crop composition and use in home gardens are constantly changing according to the needs of the owners.

In most cases, women decide what plants are grown in the home garden, because in many societies they are mainly responsible for food and healthcare within the family. They select, experiment with, and further develop species and varieties. The women own the knowledge of cultivation practices that are suited to the local environment, local species, preparation of food, and selection of medicinal plants. Often they also have a great awareness of the nutritional properties of plants and crops. In many countries, women are referred to as the custodians of agrobiodiversity.

- *GIZ, 2005: Home gardens – treasure troves of diversity*

Time line of key international events in plant genetic resources

1974
Establishment of the **International Board for Plant Genetic Resources (IBPGR)** to coordinate an international plant genetic resources programme, FAO acting as secretariat. In 1991, transformation into the **International Plant Genetic Resources Institute (IPGRI)**, in 2006 into **Bioversity International.**

1983
Establishment of the FAO **Commission on Plant Genetic Resources (CPGR)** to address plant genetic resources.

1992
The UN adopts the **Convention of Biological Diversity (CBD).**

1995
Establishment of the FAO **Commission on Genetic Resources for Food and Agriculture (CGRFA).**

1996
Launch of the **Report on the State of the World's Plant Genetic Resources for Food and Agriculture** and adoption of the **Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.**

2000
CBD Parties adopt the **Cartagena Protocol on Biosafety.**

2001
Adoption of the FAO **International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)** as a legally binding instrument.

2004
Establishment of the **Global Crop Diversity Trust** for *ex situ* conservation.

2009
Launch of the **Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture.**

2010
CBD Parties adopt the **Nagoya Protocol on Access and Benefit-Sharing.**
CBD Parties adopt the **Strategic Plan for Biodiversity 2011 – 2020, including the Aichi Biodiversity Targets.**
CBD Parties adopt the **Global Strategy for Plant Conservation 2011 – 2020.**
Declaration of 2011 – 2020 to be the **UN Decade on Biodiversity** to support achievement of the objectives of the Strategic Plan for Biodiversity and the Aichi Biodiversity Targets.

2011
Adoption of the **Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture.**

2014
Launch of the CBD **Plant Conservation Report 2014: A review of progress of the Global Strategy for Plant Conservation 2011 – 2020.**
The Committee on World Food Security (CFS) approves the **Principles for Responsible Investment in Agriculture and Food Systems.** Principles 6 and 7 explicitly refer to genetic resources.

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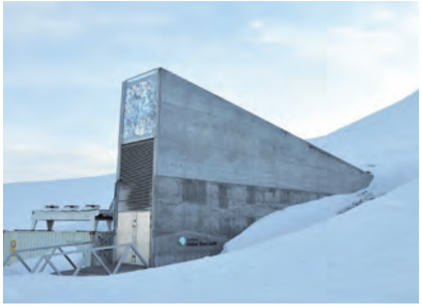

The Svalbard Global Seed Vault, half way between mainland Norway and the North Pole, is a modern-day Noah's Ark for crops. Seeds and tissue samples are stored at -18° C, in an area of permafrost without tectonic activity, 150 m inside a sandstone mountain without measurable radiation.

Ex situ conservation

The Svalbard Global Seed Vault

The Svalbard Global Seed Vault is a secure seedbank on the Norwegian island of Svalbard, about 1,300 kilometres from the North Pole. It is maintained by the Global Crop Diversity Trust, the Norwegian government and the Nordic Genetic Resources Center. It acts as a safety net for the world's food plants, against accidental loss of unique crop genetic material in traditional gene banks, and as a safeguard against climate change and other disasters that can threaten the plant diversity vital for our survival. The seeds in Svalbard are safety duplicates of gene banks. They are stored free of charge and placed in Svalbard on black box terms – only the depositor of the seeds has the ability to withdraw them. Depositors retain ownership rights over the seeds sent to the facility. Officially opened on 26 February 2008, the vault currently holds more than 830,000 samples ('accessions') of crop diversity from more than 60 institutions and has the capacity to conserve 4.5 million seed samples.

Genesys – gateway to genetic resources

In order to link all information on crop genetic resources stored in gene banks all over the world, in 2008, Bioversity International, the Global Crop Diversity Trust and the Secretariat of the ITPGRFA established the germplasm information platform Genesys. It is the internet's largest gateway through which users can discover material in gene banks around the world; it provides access to an estimated one-third of gene bank accessions held worldwide. In September 2015, Genesys contained information about 2,775,608 accessions of the world's most important food crops, with a focus on 22 crops, coming from 446 institutes.

Neglected and underutilised species

In the past, most commercial plant breeding activities have concentrated on 'major' crops, leading to overdependence on a few plant species of worldwide economic importance. Left behind were (sub-)species, cultivar groups or local varieties with under-exploited potentials with regard to food and nutrition security, health, income generation and environmental services, so-called neglected and underutilized species. (See also Bioversity, 2013.)

The reasons for being underutilized are complex and entail economic and agro-ecological constraints as well as lack of knowledge, awareness and supportive policies. With the present erosion of cultural diversity, the traditional knowledge of cultivation and processing techniques for underutilized species and their diverse uses is increasingly being lost. For the sake of modernity, local traditions might suffer a negative reputation, for example, indigenous culinary traditions and local specialties may be dismissed as old-fashioned or poor man's food.

Enhancing the use of neglected and underutilized species to better tap their potential with regard to food and nutrition security, ecosystem sustainability and adaptation to climate change has been identified as an important strategic element for developing more productive, sustainable and resilient agricultural production and food systems. Programmes promoting neglected and underutilized species have to consider the multiple functions many of them fulfil in their specific socio-ecological and economic context.

▶ *GIZ, 2005: 'Underutilized' species – Rich potential is being wasted*

Quinoa – from the Andes to the world

Quinoa is a traditional grain crop from the Andes highlands. Adapted to marginal soils and to harsh climate, it is a source of high-quality protein and important minerals. Since the beginning of the 1980s, supported by national and international institutions, this neglected and underutilized species has been experiencing a remarkable revival. Quinoa products are now on the shelves of every organic supermarket. With the increasing prices the cultivation of quinoa extended considerably – in Peru, for example, quinoa exports doubled within two years. However, the higher prices had the effect that, firstly, quinoa production expanded from the Andes to lower areas in Peru, meaning the Andean farmers lost their markets; and, secondly, that national food security reduced as poor farmers could not afford quinoa any more. For more information, see GIZ, 2013: Quinoa – from the Andes to the world.

Crop wild relatives

Another plant genetic resource that needs to be protected is crop wild relatives. These are wild plant species which are closely related to cultivated crops, including their wild ancestors – the wild 'cousins' of our cultivated plants. For plant breeders, crop wild relatives are an enormously diverse and largely untapped source of raw material for crop improvement. They may serve as source of useful genes for new traits – pest and disease resistance, or tolerance to heat, drought and other stresses. The common ancestry with crops facilitates the use of their genes in traditional and commercial breeding and biotechnology.

Crop wild relatives have made significant contributions to modern agricultural production through the characteristics that they have contributed to plant cultivars. Wild relatives have increased worldwide the productivity of important plants such as barley, maize, oats, potatoes, rice and wheat. One example for this is a wild relative of tomato that had made it possible to increase the dry matter content in tomatoes by 2.4 %. This had an economic worth of USD 250 million a year in the state of California alone. Other wild relatives have contributed resistance to pests and diseases (e.g. resistance to the grassy stunt virus in rice, see box page 2). Again other wild relatives have increased nutritional values such as protein and vitamin content.

The natural populations of many crop wild relatives are increasingly at risk, mainly due to habitat loss, degradation and fragmentation. Moreover, the increasing industrialization of agriculture is reducing populations of crop wild relatives in and around farms. Crop wild relatives are often missed by conservation programmes, falling between the efforts of agricultural and environmental conservation actions. The spread of invasive alien species (see box page 6), pollution and the growing impacts of climate change further put pressure on crop wild relatives. The wise conservation and use of crop wild relatives are essential elements for increasing food security, eliminating poverty, and maintaining the environment. For further information, see Bioversity International, 2011: Crop Wild Relatives – A manual of *in situ* conservation.

Wild plants for food and trade

Wild plants also contribute to our nutrition. Acting as a safety net in times of unexpected shortage, wild foods can play a major role in improving people's food and nutrition security. At a local level, many species contribute directly to meeting people's nutritional needs. Besides providing food to people in chronic hunger, they may overcome the dangers of the 'hidden hunger' of micronutrient deficiency. Wild foods such as wild vegetables can play a crucial role in preventing such malnutrition. In addition, they can fill cyclical food gaps like the hungry season between harvests. An example for such a wild plant used for food is the African baobab (*Adansonia digitate L.*). Its leaves, bark and fruits are used as food and for medicinal purposes in many parts of Africa. The leaves are an excellent source of protein, containing all essential amino acids (see Bioversity International, 2013).

Besides for food, many wild plants are harvested for trade, e.g. for medicinal or cosmetic purposes, such as devil's claw (*Harpagophytum procumbens*) in the Kalahari Desert in Southern Africa. This trade is internationally regulated under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In order to ensure that the wild plant-based products are collected sustainably, the FairWild Standard has been developed (see www.fairwild.org). It allows for traceability and transparency, as well as improving product safety.

- *GIZ, 2007: Partnerships for agrobiodiversity*
- *GIZ, 2015: Adding value to agrobiodiversity*

Invasive alien species – a threat to plant genetic resources

Invasive alien species are species that have spread outside of their natural habitat and threaten biodiversity in their new area. These species are harmful to native biodiversity in a number of ways, for example as predators, parasites, carriers of disease or direct competitors for habitat and food. In many cases, invasive alien species do not have any predators in their new environment, so they can spread uncontrolled. Ecosystems that have been disrupted by outside influences and are out of their natural balance are more susceptible to the colonisation and spread of invasive species.

The introduction of invasive alien species can be either intentional, as with the introduction of new crop species, or accidental, such as when species are introduced through ballast water or in cargo containers. The main carriers are trade, transport, travel and tourism, which have all increased hugely in recent years. Invasive alien species may cause economic or environmental damage, or adversely affect human health.

- *GIZ, 2010: Unwelcome guests – invasive alien species*



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Threatening aliens

One of the world's worst invasive alien species is *Prosopis juliflora*. Prosopis was originally introduced from Latin America in order to contribute to erosion and desertification control, but now threatens different areas in the Horn of Africa with environmental degradation. Ethiopia, Sudan, Djibouti, Kenya, Eritrea, and Somalia are heavily affected by the prosopis invasion. In Ethiopia's Afar Region a tremendous land mass of more than 1.2 million hectares has already been invaded at an alarmingly expanding rate per year as prosopis rapidly spreads across both pastoral and agricultural lands. Also in other areas such as Kenya's Turkana and Marsabit County, prosopis is a major driver of degradation, leading to severe losses in land and ecological functions. It challenges (agro-)pastoral livelihoods and food security in the region (see GIZ, 2014).

Plant breeding and seed distribution

It is not enough to merely conserve agricultural genetic diversity; it must also be developed further so as to improve food security, identify new utilization potential and enable agriculture to adapt to climate change. Therefore, improved crop breeding methods, breeding organizations and seed access and distribution at local level need to be promoted. So far, smallholders are rarely covered by the formal seed sector, even though this market offers considerable potential.

Open, dynamic and integrated genetic systems to cope with climate change at the local level through a combination of community-based conservation actions will improve access to genetic materials and related knowledge, and their exchange. Grass-roots breeding, participatory variety selection and participatory plant breeding will develop farmers' skills and capacity in selection in the changing context. Consolidating the farmer's roles as conserver and promoter of diversity and dynamic innovator needs to be combined with compensation or other rewards for conservation services. Activities supporting local seed systems include:

- Supporting national breeding objectives and breeding programmes with the participation of various stakeholders, including farmers, scientists, politicians and the private sector.
- Identifying and promoting superior local varieties, which can produce stable yields even under adverse conditions thanks to their high genetic diversity.
- Developing new ways to organize breeding and new models for ownership of varieties (such as open-source, see Kotschi and Wirz, 2015) with the participation of farmers' groups (participatory plant breeding, see box below).
- Supporting the propagation and distribution of seeds in smallholder areas such as through seed fairs (see box page 7, top), diversity kits (a set of small quantity of different seeds made available to farmers), community-based registers, community seed banks (see box page 7, bottom), or community-based seed production schemes.

▶ *GIZ, 2009: Biodiversity and agricultural intensification – how farmers' varieties can contribute*
▶ *GIZ, 2015: International agreements on agrobiodiversity*

Participatory plant breeding

For thousands of years, male and female farmers have been domesticating various plant species and developing a wide range of crop varieties that fit their specific needs and respective environmental conditions. Since less than 100 years ago, specialized plant breeding institutions have emerged. However, in developing countries, formal crop breeding and seed systems often fail to supply planting material of suitable quality and diversity in a timely manner and at affordable prices. Most farmers still prefer their own seed. In some regions, and for some locally important food crops, own seeds can be the only source of seed available.

Local seed systems maintain a wide diversity within and among varieties or landraces. Since farmers know best which materials meet their needs and are enthusiastic seekers of new varieties, participatory plant breeding represents a promising approach to enhancing agrobiodiversity, while also sustaining food security and alleviating poverty. In participatory plant breeding, farmers and researchers, and sometimes other stakeholders, usually work closely together to jointly redefine selection criteria and cooperate throughout the entire breeding cycle. The resulting varieties are usually greater in number, address various purposes and needs, and are more diverse, compared with the products of formal breeding programmes.

▶ *GIZ, 2005: Farmers as Breeders – Participatory Plant Breeding*

Seed fairs

Typically, seed fairs are one-day events where farmers display samples of the seeds or plant material that they use in their fields and vegetable patches. It may be the full range of cultivated species – from seed crops to tuber and root species to fruits – or the range of varieties of a single crop. Such fairs usually take place between the harvest and the new sowing season. They are also popular social occasions where people meet, exchange news and views, and eat and drink together. Here, farmers can look out for varieties they may have lost, or have always wanted to try growing. Knowledge is passed on at the same time as seeds are handed over – for example: Which site does this variety prefer?, and, What is the best use for that one?

Seed fairs can be enriched with short and easy-understandable lectures on the importance of conservation and sustainable use of agrobiodiversity, or with diversity contests, giving a prize to the farmer who displays the most diversity. Such awards underline the importance of agrobiodiversity, and also pay tribute to the achievements of those who are custodians of the cultural heritage. In addition, traditional cultural activities, for example by local dancers, singers, or musicians, will further highlight local values, culture, traditions and local knowledge.

▶ *GIZ, 2008: Markets make a come-back – Diversity displays and seed fairs*

Community seed banks

Community seed banks are local institutions that conserve and maintain access to locally adapted seed and planting materials for farmers. Besides securing access for small-scale farmers to adapted seeds at the time needed, they conserve the local genetic resource for the local and the global communities. Typically, they rely on a community storage structure where the seed can be processed, selected and stored. A committee oversees activities and decides what can be stored, and how and when seed can be used. Seed banks contribute to the security of the seed supply. Keeping the seed in a secure building administered by a committee is more likely to prevent farmers from selling off or consuming the seed in times of food scarcity.

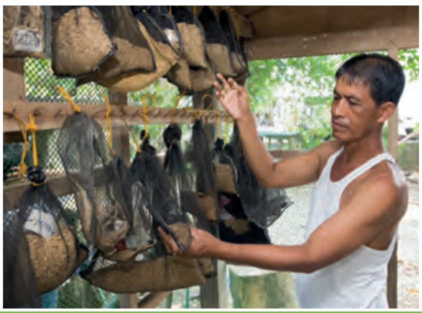
▶ *GIZ, 2008: Farmers as bankers – Community seed banks*

Outlook

Agrobiodiversity is important for nourishing people and sustaining the planet. Many initiatives – local, national, regional and international – have been initiated to stop the present loss of genetic diversity. While *ex situ* conservation technologies are well developed, there is much to be done to safeguard the diversity *in situ* and on farm. Which lessons can be drawn, which principles extracted from the experiences made, how can we further improve our efforts in conserving plant genetic resources for food and agriculture?

Effective targeting towards the needs of farmers has shown to be a key factor for success. Participatory approaches should be applied, actively involving the rural population, focusing on farmer-led activities, and local institution building and empowerment, appropriate to the local conditions. It is also important to respect the vital role of women as well as the uses of traditional knowledge. In one way or the other, farmers need to benefit from their conservation activities – either through marketing of produce or by external compensation like subsidies.

Agrobiodiversity is not a mere agricultural issue – it also tackles aspects of the environment, nutrition, education, health, water and sanitation, infrastructure and markets as well as social sciences. Depending on the objective of the project, multi-disciplinary skills and a multi-sectoral approach might be needed. The application of comprehensive strategies and innovative institutional arrangements is recommended that deal with agrobiodiversity, farming system resilience, income generation and food and nutrition security in an inclusive and holistic way. Focusing conservation strategies on a single crop is in most cases not sufficient. Development cooperation has to shift attention from species and varieties towards people and their needs. A multi-level approach is needed ranging from village interventions and capacity-building to providing policy advice and mainstreaming agrobiodiversity at local, national and international levels. Multi-stakeholder approaches, focusing on collaborative learning, innovation and institutional development should be considered.



Left: Participatory Plant Breeding builds on local knowledge and farmers' innovation.

Right: Community seed banks of Masipag farmers organizations in Quezon, Philippines, maintain at least 50 rice varieties. Planted side by side, the top ten yielders will be selected, and members can obtain such seeds for multiplication (see masipag.org).

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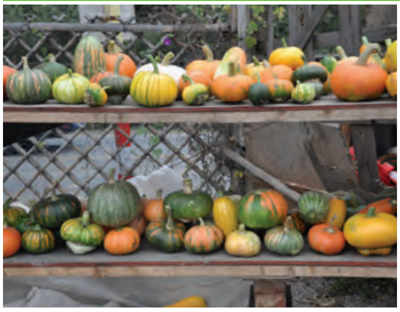

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Important links

- Association for Plant Breeding for the Benefit of Society: www.apbrebes.org
- Bioversity International: www.bioversityinternational.org
- Commission on Genetic Resources for Food and Agriculture: www.fao.org/nr/cgrfa/cgrfa-home/en
- Convention of Biological Diversity: www.cbd.int
- Crops for the Future: www.cropsforthefuture.org
- Sector Project Sustainable Agriculture (NAREN): www.giz.de/sustainable-agriculture

Further information

- Andersen, Regine, and Tone Winge (eds.; 2013): Realising Farmers' Rights to Crop Genetic Resources: Success Stories and Best Practices. www.farmersrights.org/resources/global_works_23.htm
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- FAO, 2015: Coping with climate change – the roles of genetic resources for food and agriculture. Rome. www.fao.org/3/a-i3866e.pdf

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