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Agrobiodiversity for survival

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 shows how agrobiodiversity provides food and nutrition from marginal land, and how it can buffer against short-term and long-lasting climate variations, as well as its contributions to human health. It discusses the complex relations between agrobiodiversity, disasters and emergency aid. The present loss of agrobiodiversity urgently needs to be halted.

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.

Features of agrobiodiversity for survival

Agrobiodiversity plays an important role for survival, for individual households but also for humankind – at present and in future. The broad diversity of cultivated varieties, breeds and species not only contributes to food security, but also safeguards the productivity and adaptability of crops and livestock breeds. Stable ecosystems are the very basis of human survival, far beyond their defined geographical boundaries – for instance as the most important 'producers' of clean water, fertile soil and oxygen.

Agrobiodiversity enables us to make use of environments which are inhospitable to human beings, and reduces the risks posed by pest and disease infestation, as well as changes in environmental conditions, such as floods and periods of drought. Medicinal plants can provide ingredients for basic health care. Agrobiodiversity can help to better cope with HIV/AIDS. However, disasters and emergency aid can affect agrobiodiversity – all this will be explained in the text below.

Utilization of marginal land

Over the centuries, smallholder farmers and livestock keepers all over the world have succeeded in breeding plant varieties and animal breeds which are well adapted to their respective local environments, which can survive under harsh conditions, in remote locations, without or few external inputs. Their special characteristics allow us to make use of areas where other forms of agriculture would not be possible. At the same time, the productivity and adaptability of crops and breeds is maintained.

Local crop varieties can still be productive in areas with short vegetation period, salty soils, cold temperatures, or irregular and low rainfall patterns. During droughts and scarce food

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supply, traditional plant varieties are often vitally important for rural people. In arid as well as high mountainous areas, adapted livestock are the only sustainable option for food and income production as well as an important means of transport. Modern, high-yielding varieties and breeds are often less productive in uncertain, harsh and low-input environments, and will do even less so when the weather conditions get more erratic and extreme.

Ruminants such as cattle, sheep and goats, and also yaks in the Himalaya, as well as lamas, vicunas and alpacas in the Andes, make use of areas where, due to low rainfall or high altitude, plant production is not possible. The digestive system of ruminants allows the utilization of food (fibrous plant material, roughage, cellulose) which monogastric animals such as swine and poultry cannot digest. Ruminants also have the advantage that they roam around to find their food and can be moved to different areas, such as high altitudes in summer and valley bottoms in winter, or from low-rainfall areas to areas with better grazing. Mixed flocks of different livestock breeds and species allow an optimum use of different natural resources.

Especially in drylands, agrobiodiversity plays an important role. Many dryland inhabitants are poor and depend on local plants and animals for their survival, food and income. The world's 190 million pastoralists have adapted especially well to dryland conditions. The breeds they have developed and their mobile herding strategies enable them to produce food in areas too dry for cropping. However, land-use patterns as well as social and economic conditions are changing rapidly, promoting the intensification and expansion of cropping and livestock keeping and the expansion of areas for nature conservation. Overuse of resources and inappropriate land use lead to competition for resources (grassland, water), degraded soils, desertification and the loss of biodiversity.

Food crops from drylands

Numerous food crops of global importance originate from drylands. The list includes maize, beans, tomato and potatoes from Mexico, Peru, Bolivia and Chile; and wheat, rice, barley, millet, sorghum, lentils, chickpeas, and many fruit trees such as olives, dates, figs, pistachios, almonds and plums from North Africa, Central and West Asia and the Mediterranean. The gene banks at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the International Center for Agricultural Research in the Dry Areas (ICARDA) have more than 119,000 and 131,000 accessions, respectively, from about 144 countries – cereals, food and feed legumes and forages, including cultivated varieties, landraces and wild relative species. Such gene bank holdings can be vital when diseases, conflicts and other disasters destroy the natural resource base.

Stable dryland ecosystems and agrobiodiversity are essential for dryland communities to overcome their poverty or maintain subsistence. A major challenge is how to facilitate agricultural growth without endangering the resource base. Communities are expert, but need support and conducive conditions to continue their sustainable use and conservation of dryland agrobiodiversity while getting out of poverty. For more information, see the GIZ factsheet (in the present text, GIZ factsheets, hyperlinked, are marked with ▸):

▸ *GIZ, 2011: Agrobiodiversity in drylands*

Agrobiodiversity and climate change

Agrobiodiversity and climate change are closely interrelated; they influence each other in many ways. Climate change – the rise in temperature, changes in rainfall patterns, higher incidence of extreme weather events and the increase of greenhouse gases in the atmosphere – is one of many factors reducing the diversity of crops and livestock and affecting the livelihood of the rural poor.

On the other hand, agrobiodiversity is the key for coping with climate change, at present and, even more importantly, in future (FAO, 2015a; FAO, 2015b).

The rise in temperature – commonly known as global warming – is probably the most obvious phenomenon of climate change. Temperature increase is expected to be highest in the tropics and subtropics, and the anticipated consequences there will be large-scale extinction of varieties, breeds and species, lower agricultural yields and a major change in these cropping systems. Indirect temperature effects will also be significant, including increased evaporation of water from the soil, accelerated decomposition of organic matter, and increased incidence of pests and diseases affecting both animals and plants.

Rainfall in the tropics and subtropics is expected to be reduced, but seasonal and regional rainfall irregularity and intensity will increase. Drought-tolerant plant varieties will become more important and, in extreme dry areas, camels will increasingly replace cattle. The increase of greenhouse gases will destruct the ozone layer which is expected to reduce crop yields, increase rates of pests and diseases in plants and animals and increase the incidence and severity of sunburn in animals.

However, agricultural genetic resources are not only a victim of climate change; they are of fundamental importance for adaptation to this change and are crucial to coping with the problems it poses. The *ex situ* conservation of seeds, involving storage in gene banks or botanical gardens, is essential but not sufficient. Broader and better integrated conservation schemes are needed that rely primarily on *in situ* concepts – the conservation and breeding of genetic resources by farmers and farming communities on their farms and in their villages.

Coffee adapting to climate change

Coffee is one of the world's most important export crops. Coffee requires very specific growing conditions. It is particularly sensitive to changes in seasonal temperatures and rainfall. Research findings and reports from producers in Kenya, Mexico, Peru and Nicaragua show production losses because of prolonged drought, changes in the forms of the seasonal climate, and increased crop diseases and pests. Modelling calculations indicate that by 2020 coffee yields in Mexico will decline by one-third, due large areas becoming unprofitable for coffee cultivation.

Because of the warming, the areas suitable for coffee production will shrink and shift to other locations. Production will have to move to higher altitudes – if suitable land is available. In Uganda, for example, such areas are not available and the coffee production area will decline significantly; coffee farmers will have to switch to other crops. The shift in cultivation to higher altitudes is likely to result in clearing the mountain forest, threatening wild coffee varieties and other species. At lower altitudes, the replacement of coffee plantations with other crops will affect the environmental services of these areas, such as regulation of water resources, local climate, soil cover and fire protection which, in turn, could reduce food security.

30 million coffee farmers around the world are likely to suffer declines in coffee yield because of the changing climate. The expected changes in coffee cultivation will have consequences for the entire coffee value chain – from producers, through processors and marketers, to consumers. Coffee supplies will change radically, as will investment in old and new cultivation areas. This will in turn influence service providers, the regional distribution of employment, foreign exchange earnings, and national budgets. Consumers are likely to feel the effects in the form of higher prices.

Serious impacts of the changed climate are expected in Ethiopia. Ethiopia has a unique genetic diversity of cultivated, semi-wild and wild Arabica varieties with different types of disease resistance, environmental adaptations and quality characteristics. This natural diversity is the basis for breeding coffee varieties that are adapted to the changed climate. Climate change is expected to reduce this diversity considerably.

- *GIZ, 2011: Agrobiodiversity and adapting to climate change: The example of coffee*

Plants, animals and ecosystems have the capacity to adjust to changes in factors such as heat, drought or salinity, and this enables us to cope with the consequences of changing environments. This capacity is an outcome of genetic diversity. The resistance of plants to environmental stress (e.g. drought tolerance) is a multi-genetic characteristic. It is best developed through classical breeding under *in situ* conditions. Such adaption processes, which address regional and local agro-ecological variations and offer site-specific solutions, contrast with commercial seed companies, which aim at mass-production of standardised varieties or a technology for one production system which suits large areas.

- *GIZ, 2006: Agrobiodiversity and climate change – A complex relationship*

Agrobiodiversity and human health

Through its influences in and around agricultural production systems, agrobiodiversity contributes essentially to food security and health. It is the source of the components of production and the genetic diversity within these systems that ensures continuing improvements in food production, allows adaptation to current needs and ensures adaptability to future ones. It is also essential for agricultural production systems, underpinning ecosystem services such as pollination, pest control, nutrient cycling, erosion control and water supply. Pollinators play a significant role in the production of approximately one third of global food supply. Pollination is essential to food security generally and to the production of many of the most nutritious foods in particular (see the IPBES study on pollinators, pollination and food production, forthcoming).

Ethiopia is the centre of origin of coffee. Left: Coffee is an important part of Ethiopian culture. Right: On the way to Yayu Coffee Forest Biosphere Reserve, Illubabor Zone, Oromia Regional State, Ethiopia, one of the last remaining montane rainforest fragments with wild Coffea arabica populations in the world, designated as UNESCO biosphere reserve in 2010 in order to conserve and sustainably use the wild Arabica coffee populations.

Photos: © Christine Martins

How can agrobiodiversity help in the fight against climate change?

One of the main challenges that farmers have in the context of climate change is its unpredictability. Farmers can no longer rely on the timing of seasons and the availability of rainfall through the year. Using agrobiodiversity in the fight against climate change is about responding to variety with variety. Diversity can help farmers mitigate, adapt and ensure food and nutrition security, by providing them with more options to manage climatic risks, and strengthen the resilience of their farms and the surrounding ecosystems and landscapes. Examples for such options are:

- **At the genetic level:** Different crop varieties can be used to deal with climate-induced stress and unpredictability. Planting different varieties, including drought-tolerant varieties with different flowering times, can reduce the risk of a farmer losing all of a crop in sudden climatic events. Some local varieties are hardier and better able to cope with poor soil or little water. Farmers can use these varieties to profit from areas they would otherwise struggle to cultivate.
- **At the species level:** Different crops and livestock respond differently to environmental stresses such as heat, drought, frost and salinisation. Having different species on farm prevents farmers from losing everything – some species will deal with unpredictable shocks better than others. In general, mixed crop and crop-livestock systems provide opportunities for synergy and strengthen the resilience of a farm. Nitrogen-fixing legumes and trees not only keep soils fertile, but can act as windbreaks to mitigate strong winds and soil erosion from heavy rains. Livestock can be fed with biomass from crop parts that humans do not eat and, in return, provide fertilizer for crops in the form of manure, reducing the need for chemical inputs.
- **At the ecosystem and landscape level:** Diverse sources of food and smarter seasonal planting help communities cope with 'hungry' seasons. A landscape with many different land uses helps communities and their ecosystems deal with shocks. Forests store carbon, but also reduce soil erosion, runoff and landslides during storms. Managing water, land and soil at a larger scale with practices such as terracing or storage reservoirs can help buffer the impacts of climate stress.

Source: Bioversity International (2015)

The loss of diversity from agro-ecosystems increases the vulnerability and reduces the sustainability of many production systems and has negative effects on human health.

Medicinal plants

Even today, the majority of the world's population depends on traditional medicine and, thus, on the use of plants and plant extracts. This is especially true for the population in developing countries, because natural remedies are not only cheaper than modern medicines but are often the only medicine available in remote rural areas. Medicinal plants are collected from the wild or planted in fields and home gardens, in most cases by women. Medicinal plants are easily integrated into fields with traditional crops such as maize, beans and vegetables. The different harvest times enable the farmers to distribute their income more equally over the entire year. The gathering of wild medicinal herbs frequently provides socially and economically disadvantaged groups such as smallholders and landless shepherds with their only form of cash income. Small-scale traders and industries also benefit from being able to buy dried medicinal plants and process them into teas, ointments and tinctures for not only the local but also the international markets.

GIZ, 2008: Medicinal Plants – Biodiversity for health care

The use of chemical inputs, particularly pesticides, can have severe negative consequences for wildlife, human health and for agrobiodiversity. Increasing sustainable production and meeting the challenges associated with climate change will require the increased use of agricultural biodiversity (CBD and WHO, 2015).

Agrobiodiversity and HIV/AIDS

About 70 % of all people living with HIV/AIDS live in sub-Saharan Africa, despite accounting for just 10 % of the world's population. The epidemic has tremendous effects on the continent, in economic, social and environmental aspects – the workforce is dying, agricultural production is declining, knowledge is being lost, poverty and hunger among the rural population is increasing. Agrobiodiversity is affected by HIV/AIDS and, at the same time, it affects the situation of those infected with HIV/AIDS.

Many studies have shown that HIV/AIDS accelerates the loss of indigenous knowledge and, thus, also the loss of agrobiodiversity. As the traditional way of passing on knowledge while working together is interrupted, traditional knowledge is often not passed from HIV/AIDS-infected parents to their children. Emergency sales of livestock for payment of drugs, food and funerals diminish the genetic base of farm animals.

Species diversity provides rural households affected by HIV/AIDS with the opportunity to both respond to the distinctive labour situation and ensure that all members of the family receive – as far as possible – adequate and balanced nutrition. Traditional, neglected or little-used plants are particularly suited to this purpose. They are adapted to the soil and climate, and often require less work than modern varieties; furthermore, women know how to use them, which is especially important when the husband has died.

Macronutrient and micronutrient deficiency in the diet of HIV-infected people increase the risk of infections and lead to higher mortality. Sufficient and well-balanced nutrition can maintain body weight and physical capabilities and strengthen the body's defences. The timespan between infection with HIV and the onset of AIDS can be extended. A good diet helps to prevent the illnesses and complications that often occur with HIV infection, for example, fungal diseases, herpes, lung infections, tuberculosis, diarrhoea, oral infections, nausea and vomiting. Malnutrition weakens the physical barriers and the immune defences of the mucous membranes, allowing better entry possibilities for the virus. A healthy and balanced diet is an important prerequisite for the optimal function of the immune system and is essential for successful antiretroviral treatment.

With a varied and carefully chosen mixture of plants and some animals, small farmers can make the best possible use of their land, minimise the risks posed by drought or plant diseases and improve the nutrition of their families. Good, healthy nutrition enables those affected to lead a longer, healthier and more productive life. The existing agrobiodiversity and the associated indigenous knowledge provide an opportunity for improving the living conditions of the rural population affected by HIV/AIDS. However, both genetic diversity and indigenous knowledge are subject to creeping erosion, which is being accelerated by the disease.

- *GIZ, 2006: Agrobiodiversity – an option for cushioning the consequences of HIV/AIDS*
- *GIZ, 2009: Nutrition security is key in the fight against HIV and AIDS*

Agrobiodiversity, disasters and emergency aid

Disasters affect agricultural production systems severely through the losses in plant and animal genetic diversity that accompany them. There are many consequences of either war or natural disaster, such as earthquakes, cyclones or tornadoes, floods and drought. Such crises affect agrobiodiversity differently, depending on the point at which disaster interrupts the agricultural production cycle and the duration of the interruption.

HIV/AIDS, sharecropping and agrobiodiversity

Gebreselassie et al. (2008) analysed the impact of HIV/AIDS on labour allocation, crop choice and agrobiodiversity in south-western Ethiopia. They found that HIV/AIDS caused households to increase sharecropping of their land and led to more crop species grown in the home garden. However, the impact of HIV/AIDS on labour allocation and crop diversity depended on the stage of the disease and on which family member is (or members are) affected. The observed increase in agrobiodiversity in the home garden indicates a potential that can be strengthened for improving nutrition in the context of HIV/AIDS, for example, through integrating nutrition education.

In addition, the extent of the disaster and whether all farms in a stricken region have suffered equal damage influence the consequences on agrobiodiversity. Genetic resource losses are particularly dramatic when population groups stay for prolonged periods of time in refugee camps outside of their home region's agro-climatic area.

Can seed aid do harm?

Seed interventions are the major agricultural response during emergency and recovery phases of humanitarian aid. They are implemented by diverse agencies, and widely promoted. However, seed aid suffers from a lack of critical attention, perpetuating widespread myths among practitioners, policymakers, and the larger humanitarian community. Sperling and McGuire (2010) have challenged prevalent myths about seed aid, among others, that seed aid could do no harm.

Experience on the ground contradicts this harmless image. Seed aid can pose real risks to farmers, for instance through providing the wrong crop or variety for the area, or providing it too late for farmers to sow. New diseases or pests can inadvertently be introduced. The practice of seed aid is littered with examples of this, where agencies provided long-maturing varieties when fast-maturing varieties were needed, introduced serious new weeds, introduced seeds unadapted to the stress area, or distributed seeds so unacceptable that farmers used the subsequent crop as fodder.

The promise of seed aid also poses risks to farmers, since this expectation of seed carries significant opportunity costs, such as farmers allocating precious labour to field preparation, or not seeking seeds elsewhere. If what they ultimately get from seed aid is late, or mal-adapted, they are worse off than if they had not received aid. Also, there is evidence that providing seed aid as a routine response over multiple seasons undermines the functioning of small-scale commercial seed enterprises and local markets.

Photos: © Christine Martins

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There are direct effects of disasters and their indirect consequences. Depending upon the type of crisis, direct losses during disasters can considerably destroy seed stocks in the field or in stores as well as reduce farm animal populations. Impoverishment following disasters leads to the consumption of seed and farm animals as food when no alternative is available. In addition, relief measures sometimes displace local varieties and breeds. This happens when foreign genetic resources are introduced, or when seed and farm animals are distributed that are not as well adapted to local agro-climatic conditions as local genotypes are.

If food and seed aid are not coordinated, farmers may use grain received as food aid for sowing. This involves considerable risk, because the varietal characteristics and the degree of adaptation to local conditions are usually unknown. Furthermore, local varieties of crops such as millet or maize may be contaminated by cross-pollination. One way of avoiding such problems is to distribute foreign food aid in the form of processed products, for example as flour rather than as whole grain. In addition, food provided as emergency aid might influence local food habits, which might influence agrobiodiversity.

GIZ, 2006: A basis for a better future: Agrobiodiversity and emergency response

Outlook

Genetic resources for food and agriculture are important for survival. Only a comprehensive and integrated approach can halt the present loss, and conserve and sustainably make use of agrobiodiversity. In order to ensure its conservation, all stakeholders need an increased understanding of the different aspects of agrobiodiversity. National and international law should better protect agrobiodiversity, supported by civil society, science and education as well as by the private sector. Local, national and international level interventions are needed, smartly interlinked and supporting each other.

Important links

- Sector Project Sustainable Agriculture (NAREN): www.giz.de/sustainable-agriculture
- United Nations Convention to Combat Desertification (UNCCD): www.unccd.int
- United Nations Framework Convention on Climate Change (UNFCCC): unfccc.int/2860.php

Further information

- Bioversity International, 2015: What can agricultural biodiversity do in the fight against climate change? www.bioversityinternational.org/e-library/publications/detail/what-can-agricultural-biodiversity-do-in-the-fight-against-climate-change
- BMZ and BMUB, 2014: Committed to Biodiversity – Germany's International Cooperation in Support of the Convention on Biological Diversity for Sustainable Development. www.bmz.de/en/publications/type_of_publication/information_flyer/information_brochures/Materialie238_Biodiversity.pdf
- CBD and WHO, 2015: Connecting global priorities: Biodiversity and human health. www.cbd.int/health/SOK-biodiversity-en.pdf
- FAO, 2015a: Coping with climate change – the roles of genetic resources for food and agriculture. www.fao.org/3/a-i3866e.pdf
- FAO, 2015b: Voluntary guidelines to support the integration of genetic diversity into national climate change adaptation planning. www.fao.org/3/a-i4940e.pdf

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