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Coping with Climate Change and the Role of Agrobiodiversity

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Abstract

The world's biological diversity is eroding. This concerns in particular the entire agricultural diversity of genes, species and their agrarian ecosystems, the resource base for food. With species becoming extinct, mankind is jeopardised. In this process, climate change is getting increasingly important. The most relevant climate change-related factors to agriculture are: the rise in temperature, reduced water supply and increased UV radiation. Severe implications are expected for agriculture and food supply notably in sub-tropical regions. As a consequence, a two-pronged strategy is required: mitigation of and adaptation to climate change. Agrobiodiversity plays a key in this.

This calls for a revision of present conservation approaches. Instead of ex-situ conservation in gene banks a broader concept has to be envisaged by which emphasis is on in-situ conservation and complemented by gene banks. The reason is twofold: (1) as future needs are unknown, a maximum of genetic resources has to be conserved and, at the lowest possible public cost. On-farm conservation is not necessarily less costly, but the costs are mainly borne by farmers and it produces private and public benefits, (2) adaptation of genetic resources to environmental change is necessary, a process that requires exposure to the environment, instead of being stored deep-frozen in a gene bank.

So far, there is little awareness among professionals of the close relationship between climate change and food security and the role agrobiodiversity has to play. It is imperative to manage agrobiodiversity in a sustainable way. Climate change-induced environmental stress may in fact go beyond the reach of adaptation. But the in-situ approach offers a great chance to shape a future worth living.

Introduction

The planet earth is rich. It has many millions of species - plants, animals and micro-organisms. But biological diversity is eroding. This especially concerns the entire agricultural diversity of genes, species and their agrarian ecosystems, the resource base for food. With species becoming extinct at an alarming rate, mankind is jeopardised.

1. Climate change - a menace to food security

The implications of climate change for agriculture have opened a new window in the discussion of agrobiodiversity. Environmental change is one of many factors reducing the diversity of crops and livestock. Five climate change-related factors can be identified: the rise of temperature, changes in precipitation patterns, the rise of sea levels, increased incidence of extreme weather events and the increase of greenhouse gases in the atmosphere, of which carbon dioxide is the most prominent.

The **rise in temperature** - commonly known as global warming - is probably the most obvious phenomenon of climate change. Since 1861 the global mean annual temperature has increased by 0.6°C as atmospheric carbon dioxide concentrations have risen by 32%. It is unlikely that such a concentration was ever reached during the past 20 million years (Malhi et al. 2002). Emission scenarios suggest that we will have 550 ppm within the next 40 -100 years, almost double the pre-industrial concentrations. This rise will be accompanied by a further increase in temperature (IPCC 2001). Depending on the geographical region, scientific estimates propose an additional mean annual temperature rise of 1 - 5.8°C (Caldeira et al. 2003), and it is expected that the increases will be highest in tropical and subtropical regions. Exposure of plants to increasing temperature will reduce species diversity and lower agricultural yields. A gloomy scenario is presented by Parmesan (cited in WWF 2003). It states that a temperature change of 2°C may result in a loss of some species but with possible management options at hand; with a rise of 4°C many species will be lost, with few coping options remaining. Finally a rise of 6°C will leave no more potential to adapt to climate change. As an example, the impact of temperature on coffee production in Uganda is studied by Simonett (1999). He forecasts that an increase of 2°C will dramatically reduce the area suitable for Robusta coffee. Only higher-altitude areas would remain.

Indirect temperature effects may not be less important. The evaporation of soils is increased, decomposition of organic matter accelerated, the incidence of pests and diseases aggravated (Pimentel 1993).

Changes in water supply pose another problem of increasing importance. In the last century, subtropical regions were confronted most likely with around 3% less precipitation and more frequent droughts. Contrary to this, the northern hemisphere likely experienced 5 -10% higher rainfall (IPCC 2001). At the same time, increasing seasonal and regional rainfall irregularity has been observed and scientific research suggests that this trend will become more pronounced. An indication of this is the increasing use of drought-tolerant varieties at many tropical sites. Similar trends can be observed in animal husbandry. For instance, camels are replacing cattle and goats in extremely drought-prone areas of Ethiopia (Oxfam 2002).

Among the various **greenhouse gases** it is not only carbon dioxide that matters. Chlorofluorocarbons, for instance, have severely reduced the atmosphere's protective ozone layer. And, as a general rule, each one-per cent reduction causes a two-per cent increase in ultraviolet radiation reaching the earth. Research from Hawaii suggests that a 25% ozone depletion level can reduce soybean yield by 19-25% (Teramura et al. 1990). High levels of UV radiation may also nurture pests and diseases. For example, fungus infection rates in wheat increased by 9-20% when experimental UV radiation was increased by 8-16% above "normal" (Biggs and Webb 1986).

In summary, dramatic implications are expected for agriculture and food supply. But the global trend displays enormous regional differences. Ironically, the poorest are most at risk. Fischer et al. (2002) predict that by 2080 the 40 poorest countries, located predominantly in tropical Africa and Latin America, may lose 10-20% of their basic grain growing capacity due to drought. It is also argued that many rain-fed crops in the tropical belt of Africa and Latin America are already near their maximum temperature tolerance, and their yield may fall sharply with a further rise (Richards 2003). By contrast and for temperate regions, yield increases are expected due to higher temperatures, increased carbon dioxide levels and partly higher rainfall; a country like China could experience a rise in production by 25% (Fischer et al. 2002).

Box I: Pastoralists' innovative responses to drought

"For the third year in a row [1997-2000], the southern region of Ethiopia has received insufficient rainfall and endured a deadly drought. Most of the livestock - the source of livelihood for most of the people of this region - have died and all the vegetation has withered. For many in the Horn of Africa, this drought has put them on the edge of famine for months."
In 2000, the Oxfam partner, Action for Development, purchased 120 camels, which are more drought-resistant than cattle because they only need water every 10 days or so - to be used for hauling water. The introduction of camels for water transport has freed women, who used to travel 6-10 hours to bring back as much water as they could carry. Now they can devote themselves to other activities. Camels can also be used to plough the land when there is sufficient rainfall to attempt planting."
"Today, one camel can haul more than enough water for a family. The men have assumed the task of handling the camels, freeing the women to provide care for their families and return to a variety of income-earning activities."
"Adde Lokko Aaro, a mother of six children, lost more than four hundred goats and cattle in the drought and was on the verge of financial collapse. With three camels at the disposal of her village, Adde's responsibilities have been drastically altered: '[The camels] bring enough water for a number of households at a time,' Adde Lokko said. 'They [women] don't have to carry water on their backs, our men have started getting involved in the work of fetching water, which is normally the responsibility of women. We are pleased to witness that our camels have shared our burden.'"
Cited from: Oxfam (2002)

As a consequence, a two-pronged strategy is required: mitigation and adaptation. On the one hand, all possible efforts have to be made to reduce greenhouse gas emissions and mitigate climate change. On the other, fast and appropriate action is needed to enhance capacity to adapt to changes already inherent in the system but not yet fully visible. Both, mitigation and adaptation, have to be part of anticipatory prevention strategies.

2. Agrobiodiversity - bearer of problems or carrier of solutions?

The continuous loss of agricultural genetic resources is a matter of growing concern - a process in which climate change is gaining importance. In search of adequate responses, one has to consider that genetic resources are not only a victim; more importantly, they are crucial to coping with climate change. Plants and animals with no economic value so far may become important, and new breeds able to tolerate environmental stress will be needed. But how much agrobiodiversity should be conserved to secure our future? Can we base public conservation strategies on mathematical modelling which sets priorities for conservation and the optimal degree of conservation is calculated as proposed for instance by Weitzman (1993, 1998)? Or must we conserve all we have because the future needs for human survival are unknown?

Valuing genetic resources with mathematic models is not yet relevant to decision-making. On the other hand it seems to be unrealistic to conserve all of them irrespective of any valuation. But as a basic principle it is evident that a maximum of genetic resources has to be conserved at the lowest possible public cost. Hence a conservation concept is required that goes far beyond ex-situ conservation, being the predominant approach for plant genetic resources. Storage of seeds in refrigerated banks or botanical gardens is essential. But this method exceeds the capacity of public funding, is of limited scope and of limited security (FAO 1997, GRAIN 1996). Therefore, gene banks can only be complementary to a more comprehensive conservation approach.

Such a more comprehensive approach relies primarily on in-situ concepts, managed by farmers and farming communities doing conservation and breeding on their farms and in their villages. Farmers have done so over thousands of years, have been ignored or neglected by the formal seed sector during the past 40 years and, since recently, are slowly being rehabilitated. On-farm conservation is not necessarily less costly, but the costs are mainly borne by farmers whereas the benefits are private and public.

Latest concepts of in-situ conservation follow the idea that conservation and use of genetic resources are closely linked. True to the slogan “use it or lose it”, plant species or animal breeds should be used whenever possible, should contribute to securing rural livelihoods and to rural culture. “As long as farmers themselves find it in their own best interest to grow genetically diverse crops, both farmers and society as a whole will benefit at no extra cost to anyone” (Bragdon et al. 2004).

As a consequence, economic or social benefits have to be found for seemingly useless crops or farming systems and value has to be discovered in them. Some examples of adding economic value are: wild plants may be used for medicinal purposes, wheat landraces grown under organic agriculture may get a higher price, farming communities as a whole may profit from agro tourism if they maintain their diversity, etc. However, it will not be possible to find a market for everything that should be protected. Therefore, a remainder will have to be protected without “using” it - a service that has to be paid for by the public.

3. Agricultural diversity - a main resource to cope with climate stress

Another argument that calls for a revised understanding of agrobiodiversity conservation is adaptation to climate change. This is because the ecosystem’s capacity to be resilient and adaptive to environmental change relies fundamentally on genetic diversity. Adaptation describes a plant’s, animal’s or ecosystem’s capacity to adjust to changes such as heat, drought, or salinity – an adjustment enabling them to overcome constraints, take advantage of new opportunities and cope with the consequences of changing environments.

Adaptation is a process. What matters is not so much the drought-resistant minor millet landrace, well stored in isolation and deep-frozen in a gene bank, but rather, exposure to the environment, on farmers’ fields and considering the wide agro-ecological variations of sites. Resistance of plants to environmental stress (e.g. drought tolerance) is mostly a multi-genetic characteristic best developed by “in-situ” exposure to it. In contrast, it is difficult to achieve such traits through genetic engineering.

The social dimension is no less important. Adaptive capacity building has to address the poor and should enhance their human and social capital. The focus on women addresses the fact that in rural societies everywhere women have always been the seed keepers, the preservers of genetic resources.

Such a strategy as outlined above addresses regional and local agro-ecological variations. It offers site-specific solutions contrasting with those of the corporate sector, that follows the law of economy of scales and aims to distribute a standardised variety or a whole cropping system technology as widely as possible.

Box II: Minor millets save the poor from starvation

"Sankappa is a small farmer owning three hectares of dry land in Vittalpura village of Bellary district in Northern Karnataka, India. This village is situated in the semi-arid Deccan Plateau and receives annual rainfall of 500 mm in two to three months a year, which allows one crop during July to October. Sankappa like his forefathers and other farmers of the village is growing foxtail millet. (…) The amount of rainfall during the last four years continuously dropped during the last four years in this part of the country. It was below 300 mm in 2003. 'All other crops failed due to extreme drought, and my family and livestock were saved from starvation by the harvest from foxtail millet,' says Sankappa. The (…) varieties grown and conserved by the villagers have excellent drought resistance."

"Eight minor millet crops grown in different regions of Africa, Asia and Eurasia are finger millet (*Eleusine coracana)*, proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*), barnyard millet (*Echinochloa crus-galli* and *E. colona*), kodo millet (*Paspalum scrobiculatum*), teff (*Eragrostis tef*) and fonio (*Digitaria iburua*). Little millet and kodo millet were domesticated in India."

"The long history of minor millet cultivation and its spread to different regions of the world that are notable for extremely harsh farming conditions generated considerable genetic variability in these crops. (…) Global neglect of the minor millets and increasing emphasis on few elite food crop species are precariously narrowing the food security basket. The most disadvantaged by this food production policy are the poorest of the poor (…) The shrinking number of food crops in the regional and global food basket is restricting the opportunity of farmers in difficult regions to use their land resources, environment and traditional knowledge."

Cited from: Bala Ravi (2004).

4. Make agrobiodiversity an integral part of rural development

There is little awareness among the various international development initiatives of the close relationship between climate change and food security and the role agrobiodiversity has to play. This concerns without distinction the programmes to fulfil the Millennium Development Goals (MDGs), the National Adaptation Plans for Action (NAPAs) by the United Nations Framework Convention on Climate Change (CBD 2005) and others. Adaptation to climate change in agriculture - if discussed at all - deals mainly with improved water management (in view of more frequent drought and flooding events). Agrobiodiversity - although being a fundamental resource for adaptation - is almost forgotten.

Instead, it must become imperative to manage agrobiodiversity in a sustainable way and to use it systematically to cope with the coming environmental challenges. The following aspects deserve consideration:

- Stronger coordination is needed between main global programmes such as the United Nations Framework Convention on Climate Change, the Convention of Biodiversity and the International Treaty on Plant Genetic Resources for Food and Agriculture (CBD 2003 and 2005).
- Agrobiodiversity conservation is to be made a basic component of adaptation strategies to climate change.

- Programmes that manage agricultural genetic resources require re-orientation in their strategies. Formal institutional systems based on gene banks (ex-situ conservation) must be broadened to an integrated management system that includes the farmer based (in-situ) conservation (Almekinders 2003).
- In-situ conservation of agricultural biodiversity must be made an integral part of agricultural development and be supplemented by ex-situ conservation.

Only the public sector can take the lead in implementing such a comprehensive approach, in which the private sector has an important supportive role. National and intergovernmental laws and regulations will have to provide the necessary legal frame, and civil society organisations as well as the corporate sector are more than ever in demand to fill this frame with development reality on the ground. Genetic resources must remain largely a public domain with well-balanced benefit-sharing concepts among the various stakeholders that use and conserve agro-genetic resources. Climate change-induced environmental stress may in fact go beyond the reach of adaptation. But the in-situ approach offers a great chance to shape a future worth living.

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