Agricultural Diversity in Coping with Climate Change

Bandana Shakya

Saving for winter - dried fern as fodder. Photo: Bandana Shakya.

Livelihoods of mountain communities in the world revolve around the farming system, where production is mostly subsistence based and the systems are influenced by traditions. In the last few decades, farming systems are gradually changing into the market led businesses. The global food supply shows an increase in both productivity and the production area, mainly the result of industrial and mechanised agriculture that focuses on high yields from a few crops, ignoring the other minor crops. Industrial agriculture, though the basis of the 'green revolution', is often very demanding in terms of resources and energy input compared to traditional agriculture. Besides, a dilemma of industrialised agriculture is that it benefits the wealthier communities who own large farms but relegates the poor and marginalised further into poverty. It further controls the agri-business and enhances monocropping. The diversity of farming systems is fundamental in supporting global food security. In the face of climate change affecting biodiversity, evidence shows that crop diversity plays a significant role in adapting to changing environments (Hajjar et al.2008, Zhu et al.2003). Agro-ecosystems also deliver important regulating services such as soil protection, erosion control, pollination, carbon sequestration and the maintenance of soil and water quality. Another very important aspect of agro-ecosystems is that it gives continuity to human traditions, cultures and customs. The genetic pool of modern day crops and their wild relatives is the outcome of selection processes and practices adopted by humans and nature over centuries. Further, development of molecular biology and genetic engineering, cellular fusion and tissue culture has greatly added to the genetic diversity of crop plants. Today, there are an estimated 7,000 plant species cultivated for consumption; many are yet to be studied. Among all the cultivated crops, cereals are the most important food commodities, providing over 50 percent of the daily calorie

supply and 45 percent of protein (FAO, 1998). A much wider variety of food crops such as pulses, oilseeds, yams, potato, banana and others continue to supply nutrients in diets. A vast array of crop diversity is nurtured by rich tradition and culture that is prominent at the local level. Safeguarding and protecting the rich gene pool of the crop plants is a major challenge in the context of climate change. It is also important to consider the wide range of services provided by agro-ecosystems that safeguard the production system in its entirety. The paper briefly highlights the current discourse on the impacts of climate change on agro-biodiversity and outlines the dynamics of production systems and measures for their sustenance in the backdrop of climate change.

Climate change impacts

Global warming is evident and considered to be a major factor influencing the world's living diversity, including agricultural biodiversity. The rise in temperature, changes in precipitation patterns and extreme weather events influence changes in vegetation structure, productivity and species composition. Although the extent of this influence on the nature and behaviour of agricultural crops is not clear and scientific uncertainty remains, serious implications are predicted. For example by 2080, the 40 poorest countries mainly in tropical Africa and Latin America may lose 10-20 percent of their basic grain growing capacity due to drought and many of the rain-fed crops are already under worse stress (Kotschi, 2007). Crop diversity and production can also be affected by the change in soil quality caused by the changes in soil temperature, accelerated soil-matter decomposition and changes in microfloral and microfaunal metabolism. Drought resistant crop varieties may become prevalent in the tropics while tropical crops may move to the subtropics. Changes in cropping patterns based on climatic zones may also influence the production system by altering the connection between the soil and associated biodiversity such as pollinators and decomposers. In the temperate belts, mountain agriculture may experience expansion of agriculture into the transitional zones, converting other ecosystems such as open-meadows and pastureland into agriculture fields. Complete loss of crops resulting from extreme and unpredictable weather events such as prolonged rainfall and torrential rain are also possible, although research into this area is scanty. The pressing threat to agro-ecosystems posed by climate change however, is the fluctuations in the production system making the farming system less desirable and undependable (Morton, 2007). This means reduced gross productivity from agriculture, fluctuations in world market prices of crops, a decrease in food security and reduction in the well-being of rural communities. While there are growing concerns over the depletion and degradation of agro-ecosystems, there is also an increased understanding about their potential in coping with climate change. The key for adaptation is the wide genetic base of the crop plants and their wild relatives that can support and sustain mountain agriculture for years to come.

Dynamics of the agro-biodiversity

Agro-biodiversity is the result of evolutionary changes involving constant selection of species by farmers' in their field over time. The evolutionary events of 'major gene mutation' and 'gene doubling' are significant in bringing out the desirable morphological and adaptive traits in crop plants that are advantageous in terms of increasing productivity, as well as adapting to diseases and pest infestations and harsh climatic conditions. The useful genetic variations that have developed thereby give the crop plants an advantage to grow and prosper over large geographical areas distributed at different elevation zones. Doubling of genetic entities through polyploidy has greatly expanded the yield of many important crops such as rice and wheat. The various millets grown in different parts of Africa, Asia and Eurasia present an excellent example of genetic variability accrued over the years due to their cultivation under extremely harsh conditions (Bala Ravi, 2004). Similarly, housegram and buckwheat which grow in poor edaphic and environmental conditions can have advantageous genetic composition for adaptation. It is therefore crucial to maintain the genetic pool of crop plants along with their wild relatives, since the adaptation capacity of agro-ecosystems relies on genetic diversity. Landraces are an important genetic resource base of crop plants that are subject to selection pressure and are manipulated by farmers for their various adaptive properties with moderate productivity. However, some landraces can still out-yield selected cultivars under adverse conditions (Weltzien and Fischbeck 1990). Advanced cultivars are a homogenous population of crop plants that are selected by plant breeders and are the basis of modern agriculture mainly meant for increased productivity. Wild progenitors and other close relatives of crop species are known as the 'secondary gene pool' (Harlan and de Wet 1971), and together with the pollinators and other elements of the agro-ecosystem play an important role in crop diversification and their sustenance. Dispersals by human and migratory animals have also significantly contributed to the diversification of the crop gene pool creating a 'secondary centre of diversity' or areas of favourable genetic diversification. In recent years, gene transfer in crop plants through genetic engineering has given tertiary pools for further crop enhancement and sustainability, broadening the scope for adaptation.

Conservation and management

With climate change becoming a reality and adaptation measures receiving global attention, conservation and management of natural ecosystems such as forests, wetlands and rangelands have received great attention. The agrarian ecosystem with its entire diversity of species and genes is yet to receive full attention in terms of recognition of their potential for complementing other ecosystem services and balancing food production with conservation of biodiversity. As witnessed in many mountain areas, there are issues of food security, shifts in traditional agriculture practices and loss of agro-biodiversity. Some of the minor food crops grown by mountain farmers such buckwheat *(Fagopyrum sp)*, foxtail millet *(Setaria)*, amaranth *(Amaranthus sp)*, horse gram *(Macrotyloma uniflorum)* and sesame *(Sesamum indicum)* should receive priority in conservation. To conserve crop genetic resources, the Food and Agriculture Organisation (FAO) emphasises building up an inventory of the genetic diversity of plants used for food, medicine and other purposes in traditional agricultural systems in marginalised areas such as in the mountains. There are many national and global conservation mechanisms for biodiversity such as the International Treaty on Plant Genetic Resources for Food and Agriculture, the Convention on Biological Diversity

(CBD) and National Biodiversity Strategies and Plans, that propose the protection of indigenous knowledge associated with farming systems and use of genetic resources. For the conservation and management of agro-biodiversity resources in the face of climate change, a multi-sectoral approach is needed. An appropriate conservation strategy for agro-biodiversity would be the promotion of in-situ mechanisms that involves the constant exposure of crop plants to environmental pressure, complemented by ex-situ gene banks and a horticultural garden development approach. While the protection of community knowledge and recognizing women's role in safeguarding agro-biodiversity must be a priority, it is equally important to have an incentive mechanism established for farmers to create and sustain the community gene bank, to enhance customary legal instruments to protect farmers' rights and to improve their social capital. Large-scale awareness on the relationship between climate change and food security is crucial and should be raised at local, national and regional levels.

Agricultural biodiversity thus provides many benefits to humans including food security, nutrition and livelihoods. In addition, the genetic diversity of agro-biodiversity gives species the ability to adapt to the changing environment, as well as increase their resistance against certain diseases and pests. Maintenance of crop genetic resources, domesticated and in the wild is therefore essential to ensure sustainable production of food and other agricultural products, to enhance ecosystem services and to allow adaptation to the change, including climate change.

References

Bala Ravi, S (2004) *Neglected millets that save the poor from starvation.* LEISA *India vol.6 (1): 34-36*

FAO (1998) *The State of the World's Plant Genetic Resources for Food and Agriculture*. Food and Agriculture Organisation of the United Nations, Rome

Hajjar, R; Jarvis, D J; Gemmill-Herren, B (2008) *The Utility of Crop Genetic Diversity in Maintaining ecosystem services.* Agriculture Ecosystems and Environment.123: 261270

Kotschi, J (2007) *Agricultural Biodiversity is Essential for Adapting to Climate Change*. GAIA Ecological Perspectives for Science and Society, 16: 98-101

Morton, J F (2007) *Climate Change and Food Security Special Feature: The Impact of Climate Change on Smallholder and Subsistence Agriculture*. Proceedings of the National Academy of Sciences, 104: 19680-19685

Weltzien, E; Fischbeck, G (1990) *Performance and Variability of Local Barley Landraces in Near-Eastern Environments.* Plant Breeding 104:58-67

Zhu, Y Y; Wang Y Y; Chen, H R; Lu, B R (2003) *Conserving Traditional Rice Varieties Through management for Crop Diversity.* Bioscience 53: 158-162

Bandana Shakya (*bshakya@icimod.org)* is a research associate in biodiversity, conservation and management at ICIMOD's Environmental Change and Ecosystems Services (ECES) department.