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Use of Agrobiodiversity in Adapting to Climate Change

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Globally, the rapid demographic changes occurring largely due to increasing population pressure and more recently attributed to climate change also, are likely to increase the demand for food and energy many folds. The implications of climate change are serious for agriculture, and this has brought agrobiodiversity in the forefront for dealing with climate change related events viz. rise in temperatures, changes in precipitation patterns, rise of sea levels, increase of greenhouse gases especially carbon dioxide, untimely droughts and floods, etc. The declining precipitation (both wet & dry) in the recent years and occurrence of frequent drought years has affected the agriculture and rural communities adversely. The data generated through scientific research suggests that this trend will become more pronounced in future. The most vulnerable population to this change would be poor and small holder farmers particularly those residing in Africa, Latin America and some parts of Asia. Many mitigation and adaptation measures might be beyond the reach of people living in these regions due to severe resource constraints. It is also cautioned that significant agrobiodiversity has already been lost from many production systems leaving them impoverished, vulnerable, dependent on external inputs and increasingly unsustainable. Therefore, small holder agriculture, which is >50% world over and even much higher in developing countries is tend to obscure central role in food production and key environmental systems. Traditional agrobiodiversity, which have until now less economic value, would greatly help people to cope with the changing climatic situations. The continued use and adaptive management of agrobiodiversity is central to sustainable production for improving the livelihoods, food security, and health of poor farmers.

Impacts of Climate Change

The climate change is expected to impact species both positively and negatively. Consequently, the species that have long generation times, poor dispersal, specialists/ narrow climatic tolerance, isolated populations and genetically impoverished are at more risk than those that have short generation times, good dispersal, broad climatic tolerance and are generalists. Scientists using different models have predicted that climate change would lead to development of novel climates, and/or disappearance of existent climates. When climatic factors such as temperature and precipitation change beyond the tolerance of a species phenotypic plasticity, the inward and outward movement of species resulting in change in species composition is inevitable (Parmesan and Yohe 2003). Though evidence of climate related biodiversity loss remains limited, a large number of plant and animal species are reported to be moving to higher latitudes and altitudes (Pimm *et al.* 2006, Rana and Sharma 2010). While studying climate change on the upward shift of species in the Indian Himalayan region of India, Rana and Sharma, 2010 reported that many species e.g. *Aconitum heterophyllum, Lilium polyphyllum, Sorbus lanata, Swertia chirayita, Androsace* spp., which were abundant in 1902 (Collet 1902) in and around Shimla hills were observed in 2010 in the localities mentioned but are instead found at 200-600 m above higher elevation. Species in transition zones between subalpine and alpine are especially vulnerable to climate change as they have limited scope to move further and bound to extinct due to absence of suitable migration corridors (Pounds *et al.* 2006, Rana et al., 2010). In agriculture, overall production, productivity and genetic diversity of species are also going to be affected. It is expected that some crops like wheat, rice, apple, oats may experience significant reduction while maize, pearl millet, sunflower, chick pea, soybean etc. may show some yield advantage. On the contrary, many traditional varieties, which contain significant genetic diversity may adapt to changed environments but some varieties having unique traits but narrow range of genetic variability may need support of active breeding to enhance their adaptability to the changed production conditions.

Increased temperature and water stress will also cause significant losses in production and productivity of

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livestock, especially in tropical and semi-arid production environments. Lower yields are predicted for dairy cattle as elite cattle species such as cross bred Karan-Swiss and Karan-Fries are more sensitive to heat. Buffalo being a less thermo-tolerant species will be affected more than cattle. The animal species adapted to extreme cold environments will be most affected due to warming and are bound to go extinct due to lack of migration corridors. Rising of temperature in rivers, lakes and oceans means less food and less oxygen for marine and freshwater fish populations (James *et al.*, 2008). Fish species such as snow trout and *Schizothorax* sp. generally move towards high torrential stream for breeding but increase silting and construction of dams have damaged their breeding habitats in the Himalaya (Sehgal, 1988). Changes in species interactions e.g. the utilization of a new host plant, maladaptive early hatching before host bud burst, phenological mismatches for pollinators are likely to affect the insect fauna. Microbial diversity has substantial effect on production due to changes in water availability, soil moisture retention and in the rate of acquifer recharge.

Adaptations through Agrobiodiversity

Agrobiodiversity enable us to cope with the consequences of changing environments. This capacity is an outcome of genetic diversity and its continued cultivation in the farmer's fields where it is exposed to a wide range of agricultural and ecological conditions and organism's interaction with its environment. Therefore, adaption of plant species to stress environments is different kind of genetic engineering achieved through traditional breeding and continued exposure of species to different stress environments. Besides, social institutions and women in particular whose practices and experiences often embedded in the cultures indigenous peoples constitute an important element in the strategies to cope with and adapt to climate change. However, the information on the importance of agrobiodiversity and the ways it is used by farming communities is scattered, thus need to be documented and appreciated.

To adapt to climate change, farmers usually make changes in crop production practices such as changes in varieties, crops and crop combinations, alterations in agronomic and seed storage practices, etc. In recent times, participatory plant breeding based agricultural research has also become increasingly important. Diversifications of existing genetic diversity using climate analogues, crowed sourcing approach have also been advocated as adaptation measures. These methods help farmers to ensure that their preferred materials give better return and remain adapted to changing production environments. Community seed banks and organic seed banks are being promoted at community level as seed insurance during weather uncertainties. Many civil society, farmer organization and public institutions such as MSSRF, Gene Campaign, Navdanya, Seva Mandir, Honey bee network, NBPGR, Bioversity International, etc. have been establishing community seed banks across India. The Potato Park in Peru is a locally managed community conserved area provides an important resource for coping with change and livelihood needs of Andean communities.

Most indigenous and traditional farming systems use agroforestry based land use systems and the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. It contributes to better utilization and conservation of soil and water resources, provide buffer to farmers against climate variability helps in income generation and local nutritional benefits. Examples include development of mango production systems in Bangladesh and planting of orange and lemon trees planted in Baharwala, Pakistan to promote agroforestry and multiple cropping, medicinal and multipurpose tree species in hill slopes in Western Himalayan region of India (Ensor and Berger, 2009, Rana *et al.*, 2010).

Agrobiodiversity occurring in the wild has also helped poor communities during food crisis arise due to extreme of climate change particularly drought and floods. For instance, Rendille pastoralists in northern Kenya and nomadic and gaddi tribes in Trans Himalyan region, which generally rely on their herds of camel, cattle, sheep and goats for their primary means of subsistence, look out for wild fruits and vegetables for consumption. Similarly, people inhabiting in the extreme environments of cold and hot arid regions of world collect edible plants form wild prior to expected extreme weather events and then preserved for use later (Rana *et al*., 2009).

Animal husbandry is one of the most important components of integrated farming systems, and has been considered as one the important adaptations to climate change. There are a number of breeds of sheep, goats and ponies which are endemic to and are able to withstand hazards of mountainous areas. The important breeds of sheep and goat are Rampur Bushair, Gaddi, Biangi, Gurez, Karnah, Bhakarwal, Poonchi, Kashmir

Merino and Changthangi among sheep; Chamba, Gaddi, Pashmina and Chegu among goats and Spiti and Chummarti among ponies. Homestead based enterprises such as diary, goatery, piggery, poultry, fishery, etc. provide additional insurance and capacity to cope with climate change particularly for small holders' agriculture in rural and tribal areas.

Soil and water management techniques such as micro-catchment rainwater harvesting systems in forms of terraces, earth or rock bunds, tied ridges, rock dikes, stone lines, planting pits or basins, etc. may not seem directly linked to agrobiodiversity maintenance and use, they can certainly increase the extent and use of agrobiodiversity. Aymara communities in the Andes have a long established system of rainwater harvesting in the mountains and pampas based on constructing small dams (qhuthañas) which have helped them to respond to the increased desertification of the last 50 years. Revival of a traditional rainwater harvesting system called Johads in Rajasthan and khtarees, kund in Western Himalaya have been revived as these systems recharge ground water and improve forest growth, while providing water for irrigation, wildlife, livestock and domestic use.

In addition to crop, livestock and soil biotic diversity, traditional agro-ecosystems all possess large amounts of associated diversity of plant and animal species. Mycorrhizae are beneficial associates of plants that influence plant growth in terms of increased nutrient and water absorption from the soil, protection from pathogens, increased tolerance to soil toxins, and root elongation (Podila and Varma, 2005). The ecosystem services rendered by pollinators are of great importance providing not only pollination of useful plants but also, in the case of bees, useful products and income.

Conclusion

The conservation and use of genetic resources will remain essential for improving productivity in agriculture and sustaining human existence and well being. Given that global food security depends significantly on production in more industrial agriculture, it is relevant to note the important contribution of agricultural biodiversity to global food production as well as to sustainable livelihoods is more on traditional agricultural systems (Brush and Meng 1998). It is, therefore, inappropriate to promote large-scale abandonment of biodiverse agriculture. There is a need to develop new crop and livestock varieties, use of multiple varieties or the continuing maintenance of traditional materials (crop and livestock varieties) adapted to changed (and changing) environmental conditions; maintenance and use of agrobiodiversity, both within production existing systems and through its deployment in different production systems and diversifying livelihoods. Promotion of integrated farming systems, improving water infiltration and water retention capacity, maintenance of high levels of soil organic matter, improved and accessible infrastructure and market systems, and alternative livelihoods options are needed to cope with new climatic regimes in the times to come. Blending traditional skills, knowledge, practices and experiences with new scientific developments is need of the hour.

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