

## **Biodiversity and climate change: Biodiversity as adaptation strategy to climate change, India**

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### **Author's Background**

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### **Summary**

*Diversity of small-scale farming societies in India and elsewhere represents a constant renewal of their local and traditional knowledge, and in aggregate this information constitutes an enormous wealth for humanity. Small-scale indigenous farming defends not only plant and animal biodiversity, but also a wide diversity of human cultural models, which are invaluable biological and social resources that will help us respond to the current environmental crisis.*

### **Background**

In order to adapt to changing conditions, microorganisms, plants and animals must be genetically diverse both within and among species. Biodiversity conserved and renewed in fields of small-scale farmers provides potential for the directed selection of plant and animal species that will adapt to the climate and changing resource context of tomorrow. Microorganisms crucial to resilience and sustainability of the agroecosystems likewise need to maintain diversity, and be allowed to live rather than eliminated through application of chemical pesticides, to maintain this potential. Instead of investing millions of dollars exclusively for ex-situ (off-site) conservation and laboratory research on genes, it is urgent to also support field-based conservation and participatory selection. To collect traditional varieties for storage in gene banks has been one popular technological response to genetic erosion. As of today these banks are relatively stable with moderate funding, include a wide range of collections from the majority of popular crop species, and are accessible to crop breeders for the raw material needed in crop improvement (Cohen, et al. 1991). These collections are also vulnerable, however, because the gene banks do not preserve the ecosystems that generate a wide range of crop germplasm (Brush 1993); the collections are subject to genetic drift (Soleri and Smith 1995) and they do not include diversity that arises in the field after initial collection; and most importantly, gene banks do not conserve farmer knowledge, which is an intrinsic part of this crop-based and cultural-based resource (Cleveland, et al. 1994). Traditional farmers' varieties, or landraces, are geographically or ecologically distinctive and clearly diverse in their genetic composition. Being linked to humankind's primary food supply, the landraces are an essential genetic resource. The fact that they are managed and manipulated by people has also made land races an important research topic for anthropologists, and some argue that human knowledge should be included as a component of plant genetic resources for these species that are primarily dependent on human activity (Moock and Rhoades 1992).

### **Impacts of the Green Revolution (GR)**

During the GR, many of the crop varieties the farmers were accustomed to plant and the agricultural diversity that had been developed over generations disappeared when the use of High Yield Varieties (HYV) became more common, as seen in Punjab, India, and around the world in both developed and developing countries. When traditional varieties are lost, we have discarded irreplaceable genetic combinations that had been selected and improved in each unique location.

In the early 1990s, a national campaign to protect seed varieties was started in India and called Bija Satyagraha. Bija means seed, and Satyagraha means non-violent resistance and is a well-known term in India since its use by Gandhi during the fight for independence. Initially meant to protect farmers' traditional seed rights from patents, Bija Satyagraha now also includes protection from GM seed. In 1930, thousands of Indians walked to the sea to collect salt, during the Salt Satyagraha, in defiance of the British tax on salt. Following that same spirit of independence from foreign rule, this time in the form of dominance of multinational companies, the Seed Satyagraha encourages farmers not to buy GM or patented seed, and to defy the Indian seed patent laws.

The trend of neglecting diverse seed varieties is no less prevalent in this biotechnology revolution than it was in the first GR. When companies developing GM crops are investing money and time in this endeavour, it is not profitable to provide a large number of varieties the farmers can select from, but rather to center on a very few widely adapted varieties. This way they contribute to uniformity in crops and fields of monocultures. As seen in many cases in the past, this may increase disease attacks and pests on more vulnerable monocultures, and some of the first generation of GM crops soon lost resistance to the pests they were supposed to withstand (Paul, et al. 2004).

Community seed banks and the continued use of a wide range of seed varieties in the field are therefore crucial to conserve and prevent further loss of this irreplaceable resource, and to provide farmers an alternative to HYV, new hybrids, and GM seed. The seed banks make seed available in an affordable exchange system, for example by letting

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the farmer return some seed after the first harvest. This way, farmers can access seed without taking out loans, unlike the case when they purchase the GM and hybrid seed. When farmers are dependent on returning a loan with the surplus from their crop, this can be disastrous if the crop is not good, or fails completely. The causes of farmer suicides are complex, but most observers agree it is related to indebtedness. Debt is closely tied to the cost of the seed, and the inputs they require. The risk of losing the crop, for example in a drought, is higher with hybrid or transgenic seed because these are more prone to fail in inclement weather conditions to which they are not adapted, unlike locally adjusted varieties selected in each site.

### **Local Knowledge and Climate Change**

In the village, a seed bank is often central to cooperation and reciprocity among farmers, and along with the seed the farmers exchange information about the unique varieties and how to grow various crops. In villages in Uttarakhand, India, there are often women who have the key to the seed bank and are in charge of the exchange and distribution of seed. They have customarily been engaged in seed saving and preservation, since women have long been active in agricultural work on the multi-task, small-scale farms in this hill region. The responsibility of managing the seed bank give women certain status, but it could also be regarded as yet another chore for them and extend their already numerous work hours, but is seen as part of their double responsibility for the family and for the farm. As women have to ensure that the family is fed, the seed banks are vital in conserving and storing the seed necessary for a sustainable agriculture, with crop varieties that suit their environmental conditions, and for replacement when pest attacks, droughts or other calamities would occur. Because the climate varies greatly by elevation in the hill regions, and soils vary across the landscape, different varieties are grown at each level. Those tolerant to cold and large temperature fluctuations between night and day are planted at the beginning and end of the growing season. Future climate change may well create new pest invasions or intensify those pest problems already existing. With warmer winters, insects and pathogens have better conditions to survive (Gan 2004; Garrett, et al. 2006; Gutierrez, et al. 2006; Yamamura, et al. 2006) and this is already seen for some plant pathogens (Rosenzweig, et al. 2001).

Local knowledge about the seed and its farming methods is increasingly appreciated, as science becomes aware that local varieties and knowledge about growing them have valuable aspects that can be incorporated in modern farming practices (IAASTD 2009).

### **Environmental Degradation and Organic Farming**

The soils in the hill areas of Uttarakhand have not been contaminated by pesticides to the same extent as the soils in Punjab and other intensively farmed areas of India. There is less residue of chemical pesticides there, and the water quality is therefore better. Underlying factors for this are remoteness, lack of accessibility for the industry to promote inputs, small landholdings, and lack of irrigation needed for HYV and therefore limited returns on investment in these crops. Shortage of finances among the farmers or a lack of interest in investing in nutrients from mineral fertilizers, containing nutrients which they consider already available in their immediate environment in the form of forest material and animal dung, has also contributed to this situation. Nevertheless, the hill environment is highly vulnerable and some farmers have suffered loss of soil quality due to chemical use, loss of topsoil due to deforestation, or changed character of the soil with changing climate conditions (Maxwell, et al. 2001). There is not much room for other livelihoods in these hills, but mountain agroforestry is one that has been working for centuries, and can be further improved with education of the farmers in agricultural technologies and by improving infrastructure and access to a market. Agroforestry practices improve and maintain soil fertility for the future (Jiambo 2006; Rasul and Thapa 2006; Schroth, et al. 2004), which is crucial for continued small-scale agriculture and food security for the majority of small farmers in this fragile environment.

If the farmers here were to adopt HYV and hybrids, they would need external inputs, which would have to be brought in through improved roads and would include investment in additional irrigation systems. It would be hard to maintain the crop diversity at the same time as allocating areas for the wide plantings of extensive monoculture crops. Instead, the state of Uttarakhand is to some extent supporting the farmers in choosing ecologically sound and lasting cropping practices and managing the area's ecosystems and natural resources in an integrated, sustainable way. Rather than growing hybrid varieties that are probably grown better in other areas, they can make a viable livelihood focusing on getting a higher price for their unique, indigenous varieties. There are special niche markets for beans, amaranth and finger millet, all among the sponsored products of the Uttaranchal Organic Commodity Board (UOBC), together with fruit and vegetable juices (Rais, et al. 2009).

Kheti Virasat in Punjab, Navdanya in Uttarakhand, and other community-based farmers' organizations have been able to help the farmers come together and pool their resources to reduce otherwise prohibitive marketing costs, such as for certification and labelling. They also organize the transportation, marketing and sale of their own crops. Marketing is often a key concern for smallholders (Bernet, et al. 2005). Potential market niches for small-scale farmers are networks of organic and fair-trade markets, although Navdanya e.g. focuses on meeting local food security needs and local market needs first. When considering exporting food, the local production in other countries is taken into account, and only supplemented if there is lack of a crop, or if a crop cannot be grown in that place.

When farmers convert to organic methods in these hills, they are able to sustain their livelihoods and contribute to employment outside the farm in local processing and marketing. This increased activity not only has social and economic benefits, but also contributes to less migration from rural to urban areas (Bavec and Bavec, 2006; FAO, 1996; Parrot and Marsden, 2002; Halberg et al., 2006; Kilcher, 2007; Scialabba, 2007). The UOBC is also involved in marketing strategies, and developing branding and distribution locally, but in Uttarakhand access to the market is still limited by inadequate infrastructure, poor road systems and lack of refrigerated storage or transport.

As seen in Uttarakhand, small-scale farmers with diversified production have the potential for improving both the quantity and quality of their nutrition, while conserving agro-biodiversity. "With organic farming you get a lot of produce in a small

piece of land. The farmers have realized the fact that organic is commercially profitable," said Rawat, one of the Navdanya coordinators in Uttarakhand. Panneerselvam et al. (2010) found in a study comparing organic and conventional systems in the states of Uttarakhand and Tamil Nadu that conventional and organic farming had comparable yields in most cases. In Uttarakhand, intercropping in organic systems had helped farmers increase the food available for consumption in the household. They also found that organic farmers spent less on inputs than conventional farmers, and that this reduced their risk of debt. Organic farmers are therefore better prepared when there are sudden climatic or economic changes, as they are not tied up in selling their entire crop for making debt payments, as is the case of many small conventional farmers in Punjab. It is exactly this risk of not having any flexibility in terms of income or disposal of crop, which frequently causes food insecurity and can lead to despair among the small-scale farmers in India (Panneerselvam, et al. 2010).

### **Food Security**

Food security was described in the World Food Summit as existing "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). It is more likely that farmers in India will enjoy well-balanced diets when a variety of produce is available from their own farms, and they do not need to buy additional food from the market after selling a crop. These qualities are beneficial anywhere, but particularly needed in small-scale agriculture, where food security should be given higher priority than production for a market. In terms of yield per acre, multiple cropping systems that produce grains, fruits, vegetables, animal products and their fodder produce much more than monocultures when managed well (Francis, 1986). The way several crops and intercrops are grown in sequence during the season makes use of the land, water, and nutrient resources more effective.

### **Core message and conclusions**

In order to prevent the loss of cultural wealth for later generations, the rural exodus and the destruction of farming communities should be addressed. Millions of landless farmers and their families suffer hunger and indecent living conditions in the shantytowns near cities. Their labour could be used on farms, instead of being replaced by mineral fertilizers and chemical pesticides. Farming must be something a family can sustain to make a living, in order to encourage rural people to remain on farms. Populations using forest resources must also be protected from displacement. Giving up rich agroforestry systems of great biodiversity and selling the rights to exploit these areas to new owners using systems of clear cut logging followed by large-scale crop monocultures is also a loss of a heritage of knowledge and agroecological practices.

Most of the agriculture in the world is done on small-scale diversified farms. Research for the last several years has indicated that sustainable agricultural systems such as organic farming, or other ecological ways of farming, can produce enough food to maintain food security. Jules Pretty and colleagues surveyed over 200 projects of sustainable land use in Africa, Asia, and Latin America (Pretty, et al. 2003), and while there were variations in the individual projects, the main trend was clearly toward increased yield and sustainability. These agricultural systems with low external inputs therefore increase yield while causing less negative impact on the environment. When comparing organic methods with conventional agriculture in various parts of the world, there is indication that a sustainable approach to organic farming would be a better way to produce enough food for the present population and even a larger need in the future. With sustainable methods this can be done in the same area, because farmland will not be lost to salinization, desertification or other negative impacts from chemical use and excessive water use (Badgley, et al. 2007; Bunch 1999; Pimentel, et al. 2005; Rasul and Thapa 2004; Tiffen and Bunch 2002). While industrial agriculture is net energy negative, small-scale agriculture produces more calories than it consumes. The reduction of our energy consumption therefore depends on maintaining and developing sustainable local food production, which use more human energy, the work of female and male farmers, and less energy derived from fossil fuels. Sustainable farming gives employment to 2.8 billion people around the world. If these farmers are given access to land, education and health, and are supported by food sovereignty policies, they may keep feeding the world and protecting the planet. This would be an important step in a wider strategy toward planet and ecosystem sustainability, a critical goal in a world suffering from multiple, intertwined eco-crises.

### **References**

- Badgley C et al. (2007): Organic Agriculture and the Global Food Supply. *Renewable Agriculture and Food Systems* 22 (2), 86-108.
- Bavec F & Bavec M (2006): *Organic Production and Use of Alternative Crops*. CRC Press/ Taylor and Francis: Boca Raton, Florida
- Bernet T et al. (2005): Participatory market chain approach. *Beraterinnen News* 1, 8-13.
- Brush SB (1993): Indigenous knowledge of biological resources and intellectual property rights: the role of anthropology. *American Anthropologist* 95, 53-86.
- Bunch R (1999): More productivity with fewer external inputs: Central American case studies of agroecological development and their broader implications. *Environment, Development and Sustainability* 1 (3-4), 219-233.
- Cleveland DA, Soleri D & Smith SE (1994): Do folk crop varieties have a role in sustainable agriculture? *BioScience* 44, 740-51.
- Cohen JI et al. (1991): Ex situ conservation of plant genetic resources: global development and environmental concerns. *Science* 253, 866-72.
- FAO (1996): *Rome Declaration on World Food Security and World Food Summit, Plan of Action*. FAO, Rome.
- Francis CA, ed. (1986): *Multiple cropping systems*. Macmillan Publ. Co., New York

- Gan J (2004): Risk and damage of southern pine beetle outbreaks under global climate change. *Forest Ecology and Management* 191, 61-71.
- Garrett KA et al. (2006) Climate change effects on plant disease: Genomes to ecosystems. *Annual Review of Phytopathology* 44, 489-509.
- Gutierrez AP et al. (2006): Climatic limits of pink bollworm in Arizona and California: Effects of climate warming. *Acta Oecologica* 30, 353-364.
- Halberg N et al (2006): The impact of organic farming on food security in a regional and global perspective. In Halberg N, Knudsen MT, Alrøe HF, and Kristensen ES (eds): *Global Development of Organic Agriculture: Challenges and Prospects*. Wallingford, UK: CABI Publishing. Pp. 277-322.
- IAASTD (2009): *Agriculture at a Crossroads. International assessment of agricultural knowledge, science and technology for development (IAASTD): Global Report*. Washington, DC: Island Press.
- Jambo L (2006): Energy balance and economic benefits of two agroforestry systems in northern and southern China. *Agriculture, Ecosystems & Environment* 116, 255-262.
- Kilcher L (2007): How organic agriculture contributes to sustainable development. *Journal of Agricultural Research in the Tropics and Subtropics, Supplement* 89, 31-49.
- Maxwell S, Urey I & Ashley C (2001): *Emerging issues in rural development. An issues paper*. London: Overseas Development Institute.
- Moock JL & Rhoades RE (1992): *Diversity, Farmer Knowledge, and Sustainability*. Ithaca, NY: Cornell University Press.
- Panneerselvam P, Hermansen JE & Halberg N (2010): Food Security of Small Holding Farmers: Comparing Organic and Conventional Systems in India. *Journal of Sustainable Agriculture* 35(1), 48-68.
- Parrott N & Marsden T (2002): *The Real Green Revolution: Organic and agroecological farming in the South*, Greenpeace: London.
- Paul H et al. (2004): *Hungry Corporations: Transnational Biotech Companies Colonise the Food Chain*. London & New York: Zed Books.
- Pimentel D et al. (2005): Environmental, energetic, and economic comparisons of organic and conventional farming systems. *BioScience* 55, 573-582.
- Pretty JN, Morison JIL & Hine RE (2003): Reducing food poverty by increasing agricultural sustainability in developing countries. *Agriculture, Ecosystems and Environment* 95, 217-234.
- Rais M, Pazderka B & vanLoon GW (2009): Agriculture in Uttarakhand, India—Biodiversity, Nutrition, and Livelihoods. *Journal of Sustainable Agriculture* 33 (3), 319-335.
- Rasul G & Thapa GB (2004): Sustainability of ecological and conventional agricultural systems in Bangladesh: an assessment based on environmental, economic and social perspectives. *Agricultural Systems* 79(3), 327-351.
- Rasul G & Thapa GB (2006): Financial and economic suitability of agroforestry as an alternative to shifting cultivation: The case of the Chittagong Hill Tracts, Bangladesh. *Agricultural Systems* 91, 29-50.
- Rosenzweig C et al. (2001): Climate change and extreme weather events: implications for food production, plant diseases, and pests. *Global Change & Human Health* 2, 90-104.
- Schroth G et al. eds. (2004): *Agroforestry and biodiversity conservation in tropical landscapes*. Washington DC: Island Press.
- Scialabba N (2007): Organic agriculture and food security, In International conference on organic agriculture and food security, 3-5 May, 2007, FAO, Rome. (OFS/2007/5), [www.fao.org/organicag](http://www.fao.org/organicag)
- Soleri D & Smith SE (1995): Morphological and phenological comparisons of two Hope maize varieties conserved in situ and ex situ. *Economic Botany* 49, 56-77.
- Tiffen M & Bunch R (2002): Can a more agroecological agriculture feed a growing world population? In *Agroecological innovations: increasing food production with participatory development*. Uphoff N, (ed) London: Earthscan. Pp. 71-91.
- Yamamura K et al. (2006): How to analyze long-term insect population dynamics under climate change: 50-year data of three insect pests in paddy fields. *Population Ecology* 48, 31-48.

A more extensive version of these findings is published in Nicolaysen AM (2013): *The Dark Shadow of the Green Revolution: Empowering Small Farmers in India through Organic Agriculture and Biodiversity Conservation*. Saarbrücken: LAP Lambert Academic Publishing.