Agro-biodiversity: The future of India's agriculture

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Introduction

The 1990s have been marked by an increasingly acrimonious debate over modern trends in agriculture: the controversy over the so-called Terminator technology, the scandal of the turmeric and Basmati patents claimed by American companies, the imposition of a global trading and patent regime under the World Trade Organisation, and others. Shorn of its acrimony, this debate is welcome, for it is bringing to the fore what must surely be humanity's chief concern: the security of our food supplies. Even as technology produces visions (often real, often not) of bumper harvests, and even as countries like India claim self-sufficiency in foodgrains production, over half the world's population (including tens of millions in India) go to bed hungry every day. Paradoxically, even as income levels rise in many sections of society, nutritional levels, and stability of access to food, are often declining.

There are many reasons for these paradoxes. What I would like to demonstrate in this article is that one of these reasons, the loss of biological diversity and related traditions, needs urgent attention. We can no longer afford to ignore this as a concern of the rich…for indeed this loss hits the poor the hardest, and makes farmers, and countries like India, more vulnerable to the vagaries of the global economic system.

India is one of the world's largest and oldest agricultural societies, one which as remained predominantly rural despite decades of modernisation. Even today, every aspect of the country's economy and polity, and the day-to-day lives of the majority of its 900-million populations, are governed by what happens in the agricultural sector. The stability and sustainability of its agriculture is therefore of paramount importance.

What role does agricultural biodiversity --- the diversity of agro- ecosystems, crops and livestock, and of related husbandry practices/knowledge --- have to play in this? How has the modernisation process affected the diversity found in nature and on farmer's fields and pastoralist's pastures, and will this have an impact on the paramount goal of providing food and livelihood security?

These questions have assumed special significance because of the increasing unsustainability and ecological/social dangers of the current Green Revolution methods. As farmers and environmentalists struggle against these dangers, they have also realised that there were many aspects of traditional farming which are still relevant, and that modern methods should at best supplement indigenous and local knowledge rather than displacing it.

This article attempts to:

1. demonstrate the importance of biological diversity in Indian agriculture;

2. analyse the crisis which Indian agriculture faces, especially in terms of the serious loss of biodiversity and farmer's self-reliance in the last few decades;

3. examine the widespread efforts at reviving biologically diverse agricultural practices; and

4. draw critical policy implications for Indian agriculture, outlining measures which are necessary if the goals of biodiversity conservation, productivity, and self-reliance are to be combined.

India's Agro-biodiversity

Like many large tropical countries, India is characterised by a complex mosaic of distinct agro-ecosystems, differentiated by their climatic, soil, geological, vegetational, crop-growing, and other features. A recent classification by the National Bureau of Soil Survey and Land Use Planning distinguishes 20 broad agro-ecological zones, separated by natural features and crop growing periods (Sahgal et.al. 1992). Each of these agro-ecological zones is in turn comprised of myriad micro-habitats. It is within this diversity of habitats that an amazing variety of crops and livestock have been developed over the millennia, by Indian farmers.

The Indian region is one of the world's eight centres of crop plant origin and diversity, distinguished by Russian scientist N.I. Vavilov. According to Dr. R.S. Rana, former director of the National Bureau of Plant Genetic Resources, at least 166 food/crop species and 320 wild relatives of crops have originated here (though many of them also have origins or centre of diversity in other regions). These include rice, pigeonpea, turmeric, ginger, pepper, banana, bitter gourd, brinjal, okra, coconut, cardamom, jack fruit, sugarcane, bamboo, taro, indigo, sunhemp, amaranthus, mango, and gooseberries. Species which may have originated exclusively in India include mango, taro, cucumber, pigeonpea, pepper, eggplant, and cardamom.

While the species diversity among Indian crops is significant, what is truly mind-boggling is the genetic diversity within each of these species. To give

some examples, one species of rice (*Oryza sativa*) has been diversified into at least 50,000 (and perhaps upto 200,000!) distinct varieties (Sharma, pers.comm. 1992; Sampamane 1993). One species of mango (*Mangifera indica*) has yielded over 1000 varieties, ranging from the size of a peanut to a musk melon (Negi, pers.comm. 1993); a similar figure is estimated in the case of taro (*Colocasia esculenta*) (WCMC 1992). Other crops with rich diversity in India include: wheat, sugarcane, legumes, sesame, okra, eggplant, banana, jackfruit, *jamun*, jute, ginger, turmeric, pepper, cinnamon, cardamom, sweet potato, yam, kidney beans, velvet bean, coconut.

India also has amongst the world's largest diversity of domesticated animals, with some 26 breeds of cattle, 40 of sheep, 20 of goats, 8 of camels, 6 of horses, and 18 of poultry, apart from the yak, the mithun, and several species and breeds of birds including geese, ducks, pigeons, and doves (CSIR 1970; Mohapatra and Panda 1981; Khanna 1993; Sahai 1993). It is noteworthy that the characterisation of Indian livestock breeds was last done in the first half of this century. Since no recent estimates are available, and surveys in some regions are far from complete, some scientists feel that the diversity may be even greater.

Why this diversity?

Over centuries, Indian farmers have continuously adapted and modified the rich genetic material available to them from nature. The diversity of crops and livestock is not only accidental, nor is it purely natural; it is more the outcome of thousands of years of deliberate selection, planned exposure to a range of natural conditions, field-level cross-breeding, and other manipulations which farmers have tried out. In other words, a single species of rice collected from the wild some time in the distant past, has diversified into 50,000 varieties as a result of a combination of evolutionary/habitat influences and the ingenuity and innovative skills of farming communities. This latter contribution to genetic diversity is a fact that the modern seed industry always conveniently sidesteps, and that the non-discerning consumer is ignorant of.

But why in the first place did farmers do this? One obvious answer is that different crop varieties and livestock breeds were adapted to diverse local conditions of growth and survival that were available in the country. There are sheep which are adapted to the harsh summers of the west Indian desert, and others which can survive the equally harsh winters of the Himalayan tracts. There are cow breeds, which thrive in the humid hills of the Western Ghats, while other breeds produce well in the driest regions of western India. In the Garhwal hills of the Himalaya, over 40 crop species and numerous varieties are grown, a diversity which is maintained through diverse cropping patterns, and which has evolved in the context of wide variations in edaphic, topographic, and climatic conditions, coupled with careful selection by farmers (Maikhuri et.al. 1997). This process of adaptation continues even today. Livestock

scientists recently found that migratory pastoralists in Rajasthan had selected for, and helped develop, a new breed of sheep, called kheri, in response to the increasing drought incidence and declining pasture availability (Jain et.al 1993).

Adaptation to localised environments has been only one mechanism or reason for diversification. What is even more striking is the use of a large diversity of the same crop within a single village, and sometimes within the same field. Many tribal villages in the hills of northeast India have been known to grow over 20 rice varieties within a single year in their terraced fields. In one region of Koraput district of Orissa alone, scientists identified over 1500 rice varieties (Richharia and Govindaswami 1990). In 1912, John Kenny in his book "Intensive Farming in India", wrote:

"To preach dry farming to men to whom it was a hoary tradition when Englishmen used pant instead of clothing did not appear to me the surest way to gain confidence of the Kunbi (Indian farmer), nor did I consider it wise to suggest seed selection in a land where 4,000 different sorts of paddy are grown in one province alone, and carefully differentiated according to their qualities and the land suitable to them" (*PPST Bulletin* 1982).

Within a single village, domesticated diversity can be spread over time (seasonal) and space (geographical), over vertical and horizontal layers within the same field, and within and between species of plants and animals. Many traditional communities practiced a form of agroforestry, which combined trees with crops and animal husbandry. In the high-rainfall areas of Kerala and Meghalaya, tribal communities maintained tiny home gardens which gave them wood, medicinal plants, spices, and ornamentals, apart from food (Santhakumar 1996); systems of shifting cultivation (jhum) in north-east India encouraged the use of a large diversity of crops, upto 35 species within a single cultivation cycle in some cases (Ramakrishnan 1992).

Apart from physical and biological adaptation, a host of economic, cultural, religious, and survival factors have played a role in this diversification. For instance, the late scientist Winin Perreira notes, amongst the Warli tribals of the west Indian state of Maharashtra, a great diversity of rice grown for different water and soil needs, varying maturity periods, resistance to different diseases, and various cultural events (Perreira 1992). Several varieties of rice and other crops were grown in many parts of India just for their use during festivals, marriages, or other auspicious occasions; several others were grown for their taste, colour, or smell; yet others for their pesticidal or soil-fertilisation characteristics. Diversification also provided buffer food output in times of drought, flood, or pest attack, when the main crop might fail.

The stability of a biodiverse agriculture is perhaps its most important characteristic, as recorded from many parts of the world (Salick and Merrick

1990; Altieri 1990). This is wonderfully illustrated by a once-common practice of the Garhwal Himalaya, the *baranaja*. Literally meaning '12 grains', this practice involves the sowing of a mixture of crops into a single plot of land. Rajma (beans, *Phaseolus vulgaris*), urad (black gram, *Vigna mungo*), mung (green gram, *Vigna radiata*), kulth or gahat (horsegram, *Macrotyloma uniflorum*), marsha or ramdana (*Amaranthus frumentaceous*), mandua (finger millet, *Eleusine coracana*), jhangora (barnyard millet, *Echinochloa frumentacea*), bhat (soyabean, *Glycine soja*), lobiya (*Vigna catiang*), and other crops are grown in a jumbled profusion which at first glance would appear a mess, but which probably a carefully considered way of obtaining optimal and sustained yields. Since maturity periods of these crops vary, different crops are harvested at different times, helping to retain soil moisture, and providing a constant supply of food (Jardhari and Kothari 1996). Fertility is continuously recharged by the use of leguminous plants like pulses. In addition, bunds along the fields support trees like bhimal (*Grewia* spp.), used for making rope, soap, baskets, and for fodder. According to some assessments, baranaja gives a higher overall productivity (apart from meeting diverse needs) than if the field was to be converted into a soyabean monoculture, which is being propagated by official agricultural agencies in the region (Navdanya 1993).

Apart from cultivated crops, all communities also used a variety of wild plants (and often, animals) for food and other uses. Not many studies have been carried out of the use of uncultivated plants, but where conducted, they have revealed that these are a major source of nutrition, medicine, and other requirements. Most important, they provided critical inputs when cultivation failed.

The sustainability of traditional Indian agriculture (notwithstanding its often inequitous social base) has been documented by both Indian and foreign scholars. In 1893, Dr. John A. Voelcker, Consulting Chemist to the Royal Agricultural Society of England, who had toured India studying its agriculture for over a year, wrote:

"I have remarked in earlier chapters about the general excellence of the cultivation; the crops grown here are numerous and varied, much more indeed than in England. It is wonderful too, how much is known of rotation, the system of mixed crops and of fallowing. Certain it is that I, at least, have never seen a more perfect picture of careful cultivation, combined with hard labour, perseverance and fertility of resource, than I have seen at many of the halting places in my tour. Such are the gardens of Mahi, the fields of Nadiad, and many others. Frequently, more than one crop at a time may be seen occupying the same ground but one is very apt to forget that this is really an instance of rotation being followed. Not only may there be rows of crops, side by side, as noticed above, but the alternating rows may themselves be made up of mixtures of different crops, some of them quick growing and reaped early, others of slower growth and requiring both sun and air, and thus being reaped

after the former have been cleared off. Again, some are deep-rooted plants, others are surface feeders, some require the shelter of other plants and some will thrive alone. The whole system appears to be designed to cover the bareness and consequent loss to the soil, which would result from the sun beating down upon it, and from the loss of moisture which it would incur" (PPST Bulletin 1982).

The erosion of Agro- Biodiversity

However, since traditional agricultural systems were finely interwoven with the social and cultural fabric of villages, as also with the forests and other ecological features within which the villages existed, they could not withstand the far-reaching changes in land-use, taxation, forest policy, and administrative structures brought about by the colonial government in the 19th and 20th centuries. These changes severely disrupted traditional agriculture (Dharampal 1983). But even more dramatic changes in Indian agriculture have come in the last few decades. With the advent of the Green Revolution in the mid-1960s, a handful of laboratory generated varieties have been promoted over vast areas, particularly in the plains of northern India. Given certain inputs such as irrigation and chemical fertilisers and pesticides, these varieties produce high yields (thus the somewhat misleading term High Yielding Varieties, or HYVs). It is understandable for farmers who can afford such inputs, or who have access to bank loans or moneylenders, to take enthusiastically to these varieties.

Agricultural schemes have also resulted in homogenising growing conditions, for example by surface irrigation, so that where there was earlier a complex mosaic of diverse micro-habitats, there are now immense stretches of uniform agricultural landscape. Inter-cropping is replaced by monocropping, a wide diversity of species is replaced by a handful of profitable ones, and genetic diversity within the same crop species is replaced by a narrow genetic range of financially lucrative varieties. The net effect of these and other practices has been a massive displacement of indigenous crop diversity, such that in the case of most crops now, the majority of indigenous cultivars are no longer grown.

There is no available figure for the overall loss of crop diversity in India, as indeed for the world. Some idea can be gauged by the fact that a handful of HYVs are now grown over 70% of the paddy land and 90% of the wheat land of the country (Government of India 1990). Thousands of varieties of cereals (rice, wheat, etc.), cotton, minor millets, pulses, and other crops are no longer in use on farms.

Box 1: **Crop Diversity Erosion in the Himalaya** (Maikhuri et.al. 1997)

Recent research in the Garhwal Himalaya of Uttar Pradesh indicates the extent of crop diversity erosion. Traditionally, over 40 crop species and hundreds of

varieties of cereals, millets, pseudocereals, pulses, oil seeds, tubers, bulbs, and spices have been cultivated in these hills. However, in recent times this has changed, with increasing homogenisation coming into the agricultural practices. The area under traditional crops in the Alaknanda valley, for instance, has declined substantially in the last two decades: in the case of oat (*Avena sativa)*, buckwheat (*Fagopyrum* spp.), naked barley (*Hordeum himalayens*) and legumes such as cowpea, matbean, adjuki bean (*Vigna* spp.) and horsegram (*Macrotyloma uniflorum*), the decline was to the order of 72-95%. These have been replaced by cash crops (potato, soyabean, kidney bean, mustard, amaranths). 65% of the area under hog millet (*Panicum miliaceum*) and foxtail millet (*Setaria italica*) is now used for high-yielding rice varieties and soyabean. Bhangjeera (*Perilla frutescense*), horsegram (*Macrotyloma uniflorum*), and legumes of *Vigna* spp. are almost extinct now. Several traditional varieties of rice (The British official Atkinson reported in his Himalayan Gazetteer of 1882 that there were 48 distinct varieties and thousands of nondescriptive varieties) are now hardly grown, having been replaced by a handful of HYVs.

The erosion in agro-biodiversity in the hills is due to a number of factors: (a) degradation of natural forests, which sustained traditional agriculture; (b) changing attitudes towards coarse and fine grains, the latter being considered more "progressive" to produce and consume, (c) large-scale migration for employment, causing fields to be abandoned or neglected, (d) supply of HVY seeds and other inputs at subsidized cost by the government, (e) attraction to maximise profits through cash crop monocultures, and (f) lack of incentives for marketing of traditional crops.

Livestock diversity has also faced a serious threat. It is estimated that 10 (50%) of the goat breeds, five (almost 20%) of the cattle breeds, 12 (30%) of the sheep breeds, and all the 18 breeds of poultry, are today threatened (Balain and Nivsarkar 1991). According to D.S. Balain, former head of the National Bureau of Animal Genetic Resources, the Ongole breed of cattle has already been lost to India, and is reportedly now found only in Brazil where it was imported from India (Balain pers.comm.)! The Kadaknath breed of hen has almost been pushed to extinction, as have been the Bonpalo and Nilgiri breeds of sheep (Tantia et.al. 1993).

The greatest factor in the loss of domesticated animal diversity has been deliberate cross-breeding with exotics, carried out extensively by the government in order to increase the yields of milk or other animal products. Semen banks have generally stored the semen of exotics. The policy thrust towards maximising financial profits has severely threatened species and breeds which were bred for a variety of domestic uses: the Deoni cattle of the semi-arid hills of Maharashtra, ideally suited for the climatic conditions and

fulfilling local requirements of draft, dung, and milk, has been pushed out by 'high' milk producing cross-breeds and exotics; the Aseel poultry, bred for meat, cock-fighting, and some egg production, and easily managed by poor rural women, has been displaced by exotics which are better suited for large-scale commercial farming; and so on (Ghotge and Ramdas 1998).

While all kinds of livestock are affected, perhaps the worst off is poultry; exotics now make up 80% of the total poultry population, with disastrous effects on indigenous breeds. The current thrust towards export-oriented poultry production is likely to intensify the loss.

Other factors, which have caused erosion in agricultural biodiversity, include:

1. The destruction or conversion of habitats to which breeds or varieties were specially adapted, and the disruption of traditional lifestyles, through urban migration and through displacement by development projects.

2. Changing social and religious norms, and cultivation methods, which threaten the genetic diversity of crops, especially cereals, pulses, vegetables, and plants used for religious and social purposes.

3. Intense grazing activity by cattle, which has depleted wild cereal grasses, vital sources of genes for the improvement of existing crops.

4. The clearing, in modern agricultural practice, of bunds and hedgerows, which once served as repositories of wild and semi-wild genetic diversity of crop and animal species.

5. The subtle (and not-so-subtle) changes in food habits; everywhere, people have been brainwashed into believing that wheat and rice are the only two cereals worth eating. As perceptively pointed out by Dr. P.V. Satheesh of the Deccan Development Society, the ration shops of the country's Public Distribution System (a governmental measure to make available cheap food to the poor) do not stock any of the coarse grains. Not only do people have to buy only rice and wheat for consumption but farmers do not have the incentive to grow their traditional crops since there is no guaranteed buyer. The end result: a handful of varieties of wheat and rice, have replaced many local cereals like jowar (Sorghum bicolor), bajra or Pearl millet (Pennisetum typhoideum) and ramdana (Amaranthus frumentaceous).

The impacts of Agro-biodiversity

This erosion of agricultural biodiversity threatens the long-term stability and sustainability of Indian agriculture itself, in many ways:

1. It erodes the genetic base on which scientists are depending for continuous improvement of crops and livestock. The majority of HYVs themselves have been developed from genetic material taken from traditional varieties and wild relatives of crops. These HYVs, in particular hybrids, are not very long living: they tend to lose their viability and productivity, or become increasingly susceptible to pest/disease attacks, within a few years. This necessitates the infusion of fresh genetic material, which is again obtained from existing traditional varieties or from wild plants. But then the introduction of these HYVs is itself a major cause of the erosion of traditional crop diversity. Some of this diversity can be stored in gene banks and accessed when needed (see below), but there is an inevitable loss even in such storage, and the continuous evolution of new varieties, which was taking place on the farm, is no longer happening. As has been said, modern agriculturists are somewhat like masons building the roof of a house by taking the bricks from the walls!

2. The failure of a single HYV crop due to any natural calamity is a crippling blow for a farmer who has no other crop to fall back on, unlike traditional agriculture where some fall-back crops were also grown. Some degree of security against such eventualities can be artificially achieved by measures like protective irrigation, subsidies, and credit schemes, but such measures are expensive and prone to failure. In the Garhwal Himalaya, for instance, data for the periods 1970-74 and 1990-94 show that yields of most traditional food crops remained stable, and that the recent food insecurity or shortage problem is largely due to the decline of these crops (Maikhuri et.al. 1997; see Box 1 above). For the country as a whole too, the increasing reliance on a narrow genetic range of crops represents a high-risk proposition.

3. Both the above features result in an increasing dependence of the farmer on the industry-dominated market and the government. Virtually all inputs for farming, except land and family labour, are now obtained from outside the village: seeds, irrigation, fertilisers, pesticides, credit. And despite huge subsidies on these inputs, as also support prices and the like, an increasing number of farmers are facing the economic treadmill, spending more and more to achieve the same output. Some commentators have observed, somewhat controversially, that at least part of the unrest in places like Punjab and eastern Uttar Pradesh is because of the frustration of farmers trapped by the short-term lure of the Green Revolution (Shiva 1991).

4. Several other effects of modern farming have brought insecurity in the lives of farmers. For instance, the traditional paddy field in northeastern, southwestern, and central India provided not only rice but also fish, frogs, and other elements of biodiversity which were an important part of the diet of several communities, especially tribals. Modern paddy fields, which require large amounts of chemical fertilisers and pesticides, are devoid of much of this biodiversity, with a resultant loss of nutrition for farmers. Similarly, in the Western Ghats, e.g. of Kerala, farmers grew a profuse mix of fruit trees and

food crops on slopes, along with paddy in the valleys; the former is now increasingly being replaced by plantations of single cash crops like tea, so that there is a heavy dependence on the market for food requirements.

Dr. R.H. Richharia, one of India's most eminent rice scientists, and the late head of the Central Rice Research Institute, put it in the following way:

"The traditional agricultural systems and sciences as practised in India and South East Asia have been, to a great deal subverted in the past 25 years. The rice farmer who has a proud history of plant breeding and scientific eco-specific cultivation is today turned into a cog in the wheel of the agricultural 'sector' where his fund of knowledge is considered only as 'tradition'. The tremendous onslaught of western ideas and approaches and the devaluation of farmers' own knowledge and wisdom have most critically affected the marginal and small farmers who form the backbone of our agriculture." (Indian Society for Rural Gene Banks 1992).

Box 2: **The Erosion of Homestead Biodiversity** (Santhakumar 1996)

Traditional homestead gardens in Kerala have been a major source of household requirements. Apart from non-paddy staple food (tubers, jackfruit, etc.), these gardens provided non-staple food (e.g. fruits), timber and other house construction materials, biomass energy, fodder, organic manure for the fields, medicinal plants, edible oils, spices, even material for clothing. Over the last 4-5 decades, however, this traditional practice has considerably declined. Coconut plantations or other land uses have taken over. As a result, a number of plants grown in homesteads have disappeared or declined substantially, with negative effects on both people and the environment. For instance, anjili (*Artocarpus* spp.), used for timber, has vanished, thereby increasing the dependence for timber on natural forests. Laurel, used for non-edible oil, has declined, thereby reducing the supply of a cheap energy source. Organic manure from a number of plants has reduced drastically, increasing dependence on costly and ecologically damaging chemical fertilisers. Farmers may have gained in terms of short-term monetary returns (e.g. from coconut), but they have lost out on many other gains, and are likely to suffer even financially in the long term.

The impact of globalization

The 1990s have seen a major shift in India's economic policy, away from goals of self-sufficiency and public sector towards an 'open' economy and privatisation. While there was undoubtedly a need to reduce bureaucratic hurdles and top-heavy administration, the new economic policies appear to be throwing out the baby with the bathwater (Kothari 1995). In the field of

agriculture, there has been an aggressive thrust towards commercialisation, especially to feed an insatiable export market. Cash cropping, already a threat to the small-scale biodiverse farm, has been given a major boost. New trends include floriculture, industrial aquaculture, and other forms of intensive farming which leave little scope for biologically diverse production systems. Perhaps most devastating are recent moves by the Indian government and some state governments to relax land ceiling and other regulations which restricted the conversion of agricultural into non-agricultural land (Kothari and Kothari 1995). The intent is clear: make it easier for industrial level agriculture, or even non-agricultural land uses such as industry, to acquire land.

The parallel move towards more high-technology agriculture makes the country as a whole also more insecure, as it increases its dependence on biotechnologies controlled by industrial countries and multinational corporations. The entry of Cargill, Cieba- Geigy, Monsanto, McGain and other globally powerful companies into India's seed and agro-products sector is a major step towards this crippling dependence, and a direct reversal of policies which had all this while tried to take us towards self-reliance. The benefits and risks of genetic manipulation and other biotechnologies are currently being debated all over the world. Acute focus has been on the controversy surrounding the so-called "control of plant gene expression" technology which will make second generation seeds sterile (earning it the title "terminator technology", coined by the Canadian group RAFI), and thereby force farmers to buy seeds every time from the manufacturer. Apart from the ecological risks, one aspect which has been less focused on is the fact that most such biotechnologies are likely to remain beyond the reach of the small farmer (and for that matter the small seed manufacturer, who along with farmers themselves still serve the majority of the seed needs of Indian agriculture). These developments can only deal a further blow to farmer self-sufficiency.

This process of homogenisation of agriculture, and increasing dependence on alien agencies and technologies, is likely to be greatly intensified with the implementation of the General Agreement on Tariffs and Trade (GATT), concluded in 1993. This requires countries to greatly "open up" their borders to both imports and exports, and substantially reduce governmental controls and interventions.

Furthermore, the provisions in the Trade-Related Intellectual Property Rights (TRIPs) part of GATT, especially those seeking to harmonise IPR regimes across the globe and to enforce patentability of life forms, are forcing changes in the Indian Patent Act and related legislation (see Box 3). This could have severe implications for biodiversity and farmers' rights. IPRs are expensive, and corporations would try to push their protected seeds over as wide an area as possible to recover costs and make profits. Further displacement of traditional diversity and homogenisation would result. Additionally, innovations by

farmers, which result in expanding diversity, may be hindered if IPR regimes favour the formal sector breeder at the cost of the farmer.

Box 3: **The Plant Varieties Act: Breeder vs. Farmer** (Kothari 1999)

By late 1998, the Ministry of Agriculture of the Government of India had finalised a draft Plant Varieties and Farmers' Rights Protection Bill (PVFRPB 1998). This was stated to be the country's response to the requirement, under TRIPs, that every country have either a patent regime or an "effective sui generis" system of providing intellectual property rights to new plant varieties. What is "effective" has never been defined, but India appears to have chosen the model set by the Union for the Protection of New Varieties of Plants, which has an international convention (UPOV 1978) for this purpose. UPOV was formulated almost exclusively by industrialised countries, and has been increasingly modified to benefit the corporate seed and agro-products sector.

The PVFRPB purports to protect the rights of both formal sector breeders (scientists, corporations, organisations) and farmers. However, it leans heavily towards the former, and thereby reveals the leaning of the government towards corporate/formal agricultural R&D. Farmers' rights are restricted to the ability to save, use, exchange, share, or sell (except sale for the purpose of reproduction under commercial marketing arrangements), varieties which are given IPR protection. While providing breeders the possibility of receiving IPRs (and thereby exclusive marketing rights for a specified period), the Act does not provide corresponding protection to the varieties and knowledge developed by farmers over millennia. It gives no incentives to farmers to continue innovating. The national authority which is to be set up under the PVFRPB does not contain a single farmer, or even a single NGO.

However, the PVFRPB is by no means a complete sell-out. Apart from the farmers' exemptions mentioned above, there are critical clauses which allow the government to exclude plant varieties from the purview of IPRs if necessary in public interest, or to compulsorily license protected varieties to other breeders if it is felt that the IPR holder is acting against public interest. Farmers' can appeal to the relevant authority if they feel that their variety has been used by an IPR holder, and receive appropriate compensation if their appeal is upheld. However, given the less than demonstrated ability of the government to act in the interests of small farmers and local communities, there is not much confidence that it will use these clauses very often. Clearly, a more explicitly farmer- and biodiversity-oriented legislation is necessary. So too are mandatory clauses to conduct environmental impact assessments to ensure that new varieties do not displace traditional biodiversity.

Finally, even as we give in to the TRIPs diktat that plant variety protection be introduced, the country must continue debating the ethical, political and other issues surrounding IPRs on life forms and critical knowledge sectors, and leading a struggle against such IPRs.

Opportunities for conservation

A considerable amount of the genetic material which has been grown or bred by farmers may no longer be available in the field, but has been collected and stored in gene banks and breeding stations. The National Bureau of Plant Genetic Resources and the Indian Council of Agricultural Research, in their network of gene banks, have several hundred thousand accessions. Such ex-situ collections are important, as they are able to store material which may no longer be possible to grow in the field, and as they make available the base material for genetic upgradation of agriculture.

But such collections also suffer from severe limitations: they are very expensive, lack adequate space to store the complete genetic diversity found in agriculture, and suffer loss of viability of stored germplasm. They also freeze evolution, since the environmental conditions which crops are constantly adapting to cannot be recreated in the icy chills of the gene bank. Finally, they have various political problems associated with them; on the one hand, farmers experience considerable difficulty in accessing the genetic material, and on the other, there is relatively easy access to formal sector breeders and corporations who use the material for commercial benefit.

For this and other reasons cited above, there is no alternative to the conservation and continued use of crop and livestock diversity in- situ, i.e. on the farmers' fields and the pastoralists' rangelands. Unfortunately this aspect has been almost completely ignored in governmental programmes, with the exception of some efforts to encourage continued use of traditional livestock breeds (see below). However, in- situ conservation of crops is finding increasing attention in the work of community organisations and NGOs. Farmers in many regions are beginning to compare their indigenous biodiverse forms of agriculture with the modern monocultures, and at least some of them are coming to the answer that a revival of the former, with appropriate modern inputs where necessary, is preferable to running on the economic treadmill of the latter.

Actually, a revival or development of a biologically diverse agriculture is eminently possible in India, since the destruction of traditional diversity is not yet irreversible. Consider the following:

1. The Green Revolution technology has not spread to many parts of the country, for several reasons, including its exorbitant costs, and lack of appropriate packages for so-called 'marginal' areas (mountains, flood-prone

areas, arid zones....). This means that a lot of traditional agriculture still survives, retaining with it considerable diversity of crops and livestock, and the knowledge and practices associated with them. The example of Tehri Garhwal given below is illustrative.

2. Even where new HYV crops and cross-bred or exotic livestock breeds have been introduced, in many areas they have failed to produce the necessary results, or have not performed to the satisfaction of farmers. This is especially true of 'marginal' areas. In many cases, therefore, farmers have reverted back to their indigenous varieties, or continue to grow these varieties along with the HYV ones, as insurance against the failure of the latter.

3. There is a certain resilience to change (what agricultural scientists call "stubbornness" or "backward mentality") amongst Indian farmers, which has helped to retain elements of traditional diversity and practices even in areas where the Green Revolution has been aggressively pushed.

4. There is a tendency of many farmers to grow HYVs for the market, but their traditional varieties for home consumption. This has been found in areas which are converting to intensive modern farming in Rajasthan, Andhra Pradesh, the Himalayan foothills in Uttar Pradesh, and elsewhere. Agricultural planners would call this "double standards", but the farmer is simply combining the possibilities of earning good remuneration (made possible more by an economic system which subsidises and favours these HYVs than by any inherent characteristic of HYVs), with the personal desire to eat healthy food. Again, considerable on-farm diversity may exist because of this.

But apart from the above, most exciting is the deliberate attempt by groups and individual farmers to revive agricultural diversity. This revival could be because of economic, environmental, spiritual, or other reasons, and is taking root in many parts of India.

The revival of diversity

The frightening implications of the erosion of agricultural biodiversity are only now beginning to dawn on the country's establishment, though they have been apparent to the non-governmental sector for much longer. This realisation is within the context of a worldwide scurry to retrieve lost ground, or at least to safeguard from activities which could cause a loss of the remaining diversity. The International Technical Conference on Plant Genetic Resources at Leipzig, Germany, in mid-1996, noted the "serious threats to the security of plant genetic resources" and stressed that "efforts to conserve, develop, and sustainably use genetic diversity should be improved" (FAO 1996). A series of meetings and workshops have also been held in the 1990s on the subject in India; for instance, in 1993, the National Bureau of Animal Genetic Resources and other organisations held a major national conference on indigenous

livestock diversity; in 1995, the International Development Research Centre sponsored a meeting on how to encourage on-farm use and maintenance of genetic resources, which resulted in a fund being created to enable groups to carry out such activities (Sperling and Loevinsohn 1996) (see Box 4).

Box 4: **The Using Diversity Fund**

Following a meeting on on-farm use and maintenance of genetic resources, organised by the Canadian International Development Research Centre (IDRC) in 1995, a fund called "Using Diversity Award" was created for such initiatives. Managed by a group of individuals and NGOs from India, Bangladesh, and Nepal, the Award is aimed at encouraging a range of activities relating to agro-biodiversity in the South Asian region. In 1996-98, 12 such initiatives were funded. They included, in India: documentation and conservation of fodder and forage plants for livestock use in Maharashtra and Andhra Pradesh; assessment of farmers' perceptions and traditions relating to agro-biodiversity in Andhra Pradesh; promotion of vegetable and spice diversity in Gujarat and Rajasthan; mapping of crop diversity knowledge in Gujarat; assessment of shifting cultivation and biodiversity inn Maharashtra; promotion of rice and millet diversity in Madhya Pradesh; and documentation of agro-biodiversity knowledge in Uttar Pradesh. In Bangladesh and Nepal, the awards were granted for documentation of the use of uncultivated foods, and participatory breeding and evaluation of rice, respectively.

In the Hemval Ghati of Uttar Pradesh, among the Himalayan foothills, some farmers under the banner of the Beej Bachao Andolan (Save the Seeds Movement) have initiated a quiet revolution (Jardhari and Kothari 1996; Prasun 1996). A few of the Andolan's members, like Vijay Jardhari and Raghu Jardhari, both small farmers, have been traveling in the region collecting seeds of a large diversity of crops. Though the area has largely taken to HYV paddy cultivation, they report that many farmers still grow indigenous crops in small plots adjacent to the commercial varieties. For the last few years, Vijayji is trying out these indigenous seeds in experimental plots over about two acres: in all, he has tried over 150 varieties of rice, an equal diversity of beans, 40 varieties of finger millets, 8 of wheat, and a diversity of other crops and tree species.

Vijayji maintains meticulous records of the varieties he grows, as also of whatever information he can get from other farmers in the region who are using indigenous varieties. He has a herbarium with over 120 cultivars of rice,

giving details of local names, growing period, grain colour, and other characteristics of each variety: thapachini (tall, high-yielding, non-lodging), nagni basmati (red and white grains, nice aroma), gorakhpuri (fast-growing), chowari (red grain, high-altitude tolerant, starchy), bangooi (black-stemmed, used every three years so that weeds stand out in contrast and can be removed)...

Nor have these farmers restricted their activities to their own fields; they are actively encouraging other farmers in their villages to adopt some of the traditional seeds which they have found useful for some characteristic or the other. Initially they met with resistance, since farmers using HYVs were not confident that traditional varieties would earn them a similar livelihood. However, some farmers who had begun to feel the pinch of rising input costs, or who were conscious of the health and ecological implications of using chemicals, did take the advice. On a visit to Vijayji's village Jardhar, I met some farmers who he had influenced; they told me that they were in the process of completely switching back to organic farming with some of the indigenous paddy and other crop varieties, and expected to be economically much the better off for it, since they could now forego expensive chemical and seed inputs. They pointed out that some of the traditional paddy varieties, like thapachini, performed as well as HYVs, needed lesser inputs, and produced more fodder material.

Interestingly, Vijayji and other farmers in the village also pointed out wildlife which occurred on their organic fields: spiders, frogs, butterflies, earthworms. They were conscious of the fact that some of these animals helped to control pest populations, or to maintain soil fertility, and that they did not survive in chemical-intensive farming.

Other members of the Beej Bachao Andolan, like Saab Singh of Lasiyal village, Dhoom Singh Negi of Khadi village, and Bhupal Singh Krishal of Nahin-Kalan village, are now attempting to spread biodiverse organic farming in their regions, and report results similar to Vijayji's. A series of *padayatras* (foot marches) have taken them into remote areas of the region, collecting and spreading traditional varieties. Though their influence in the region is as yet miniscule, it is growing, and the Andolan has no doubt that as more and more farmers realise the treadmill that the Green Revolution has trapped them in, they will turn to a revival of biodiverse farming.

The Beej Bachao Andolan is just one of dozens of networks and organisations, and perhaps tens of thousands of farmers, who are rediscovering the value of biologically diverse agriculture. Navdanya is a large network of farmers, environmentalists, scientists, and concerned individuals which is working in different parts of India to collect and store indigenous crop varieties, evaluate and select those with good performance, and encourage their reuse in farmers' fields; it has also produced a series of useful readers on the issue (Navdanya

1991; Shiva et.al. 1994; Shiva et.al. 1995). Then there are the Academy of Development Science and the Indian Society for Rural Gene Banks, working with farmers in Maharashtra to document their rice diversity, set up community gene banks (currently holding over 300 rice varieties from western India), and propagate selected varieties. Some of these varieties have been reported by these groups to be as high-yielding as the modern HYVs. In a highly eroded region of Andhra Pradesh, the Timbuktu Collective is trying out organic farming and has started a grain bank of indigenous crop varieties. Also in Andhra Pradesh, the Deccan Development Society is working with tribals to revive crop diversity. At Melkote, a historic temple town in Karnataka, a veteran Gandhian is experimenting with organic farming and indigenous varieties with the help of physically handicapped children and mentally disturbed adults. There are thousands of other such groups, individual farmers, and networks, which are doing similar work in various parts of India (Alvares 1996; see also Box 4).

Another interesting development towards revival and sustenance of agro-biodiversity is the move to help villagers to document this diversity. Several NGOs and individuals are currently involved in building up Community or People's Biodiversity Registers (see Box 5), which record the variety of uses that communities make of biological resources. Navdanya's efforts in this direction, mentioned above, have resulted in the documentation of several hundred varieties of rice, millets, and other crops in selected sites across different biogeographic regions of India. These documents are not only evidence of diversity, but also the means whereby communities can assert their rights to the knowledge and resources recorded therein, and serve as a major moral boost to efforts which otherwise seem doomed in the face of the juggernaut of agricultural homogenisation.

Box 5: **Community or people's biodiversity register** (Gadgil 1996; Bhatia and Kothari 1996)

Local communities have for centuries been using and conserving the biological resources found around them. In the process, they have developed knowledge, skills, and techniques (K/S/T) related to these biological resources. At a time when the world is looking for sustainable forms of resource use, these systems have great relevance. Unfortunately, in recent years, they have been rapidly eroded by the impact of modernisation. Also, significant elements of these knowledge systems have, over the years, been appropriated by commercial interests, with little benefits flowing back to local communities. These issues have become a part of global debates on biodiversity and indigenous communities.

Traditional knowledge systems have usually been orally transmitted, and are not recorded. While this method of transmission may have sufficed in earlier times, and must continue in its richly varied form, there is also a need to document these traditions in some form. In this respect, Indian groups and

networks involved in environment, health, agriculture, and traditional science and technology, have taken an interesting new initiative. They have prepared a draft format called the Community or People's Biodiversity Register, which is aimed at documenting, at the village level, community and individual K/S/T related to biological resources. The aims are multiple:

a) revitalizing traditional knowledge/skills/techniques;

b) protecting traditional/customary rights of local communities by providing proof of resource uses;

c) assessing the economic value of community usage and conservation practices;

d) priority setting for conserving those resources which are under threat;

e) recognizing outstanding K/S/T for rewards;

f) sharing the local knowledge with other communities in India for mutual benefit; and

g) protecting local K/S/T from exploitation by commercial users (including protection against imposition of intellectual property rights by outsiders), by providing proof of prior use, and giving the possibility of enforcing prior informed consent of the concerned community.

Presently, with the help of community-based organisations, such Registers are being formulated in several dozen villages all over the country. Detailed information on the relationship of villagers with their biological surrounds is being recorded, both in text and visual form. In a remarkable move, the Ministry of Rural Development has sent a circular to all state governments, urging such registration in all *panchayats*. This may be somewhat premature, as the capacity to conduct such an exercise is probably very limited over most of India. There is therefore an urgent need for widespread education and training initiatives. The Ministry of Environment and Forests has also finally accepted the critical need to protect these documents from becoming conduits for further piracy of knowledge and resources, by adding a general clause regarding the protection of indigenous knowledge by registration processes, in the proposed Biological Diversity Act (see Box 6). Some legal experts feel that this may not be enough to qualify these documents as evidence before patent offices, but this will have to be tested in the near future.

Other exciting innovations are taking place in the field of marketing of biodiverse produce. As in the west, consumers in India too are increasingly getting worried about the poisons they are eating in their daily diet; indeed, recent research shows that a substantial proportion of the foodstuffs in the

market in cities like Delhi have pesticide residues which are above the recommended safety limit (Gupta 1986). Widespread publicity about this is converting the discerning consumer into a person who would prefer buying organic food, if he/she could. A small survey in the early 1990s in Delhi revealed that people from diverse backgrounds were keen to get such food, and many were even willing to pay a slightly higher price than its chemically-impregnated equivalent; the survey also revealed a number of outlets, who were willing to stock and separately display organic food (Amin et.al. 1991).

As a small step towards this, groups in Delhi, Bombay, Bangalore, Pune, and other cities have set up direct links with farmers who are growing food organically (Alvares 1996). Some of these networks are also encouraging farmers to grow their indigenous varieties, which in any case often do better than new HYVs under organic growing conditions. The environmental action group Kalpavriksh, for instance, has linked up with the Beej Bachao Andolan members, and is helping to market some of the traditional varieties of beans, rice, and other crops in Delhi. It is also helping the villagers to build up a Community Biodiversity Register, and to revive some traditional uses of trees and fruits, such as soap-making from the bhimal tree (*Grewia* spp.), oil and bath-scrub production from wild apricot, and others, for both domestic consumption and sale outside. However, these and other efforts have run into serious marketing and quality control problems, which illustrate the urgent need for policy level interventions which would put needed resources and infrastructure into tackling such problems.

Indeed, the necessity of in-situ conservation of crop and livestock diversity has finally come home to the government too. The National Bureau of Animal Genetic Resources (NBAGR), the central agency dealing with livestock diversity, has of late initiated some schemes to encourage farmers and pastoralists to continue or revive their use of indigenous breeds. The National Bureau of Plant Genetic Resources (NBPGR), the NBAGR's crop counterpart, is also exploring possible schemes to encourage on-farm conservation of crop diversity. Recently the Kerala government in south India announced a renewed thrust towards mixed fish-paddy cultivation systems, to replace the HYV paddy fields. A comprehensive action plan and legislation on biodiversity, being formulated at the Union Ministry for Environment and Forests as a follow-up to the Convention on Biological Diversity, also propose to include measures to check the erosion of agricultural diversity (see Box 6).

Box 6: **The Proposed Biological Diversity Act, 1998**

The Government of India, in a follow-up action to the international Convention on Biological Diversity, has drafted a Biological Diversity Act (BDA 1998). Set to go to Parliament by early 1999, the proposed Act aims to conserve biodiversity, achieve sustainable use of biological resources, and ensure equitable sharing of

the benefits arising from such uses. Amongst its important provisions, with relevance to agro-biodiversity, are the following. It:

1. prohibits transfer of Indian genetic material outside the country, without specific approval of the Indian Government through a due process;
2. stipulates that anyone wanting to take a patent or other intellectual property right (IPR) over such material, or over related knowledge, will have to seek permission in advance;
3. provides for the levying of appropriate fees and royalties on such transfers and IPRs;
4. regulates access to such material by Indian national also, to ensure that there is some control over over-exploitation (e.g. of medicinal plants), and that there is some sharing of benefits to all concerned parties; however, it provides some relaxation in the case of research;
5. provides for measures to conserve and sustainably use biological resources, including habitat and species protection, conservation in gene banks, environmental impact assessments of all projects which could harm biodiversity, and so on;
6. empowers local communities to have a say in the use of resources and knowledge within their jurisdiction, and to enter into negotiations with parties who want to use these resources and knowledge;
7. provides for the development of an appropriate legislation or administrative steps, including registration, to protect indigenous and community knowledge;
8. empowers governments to declare Biodiversity Heritage Sites, as areas for special measures for conservation and sustainable use of biological resources, as also notify threatened species to control their collection and use;
9. stipulates that risks associated with biotechnology (including the use of genetically modified organisms), will be regulated or controlled through appropriate means;
10. provides for the designation of repositories of biological resources, at national and other levels.

The BDA envisages the creation of Funds at local, state, and national levels, which will be used to support conservation and benefit-sharing activities. These funds will be generated from fees, royalties, donations, etc. The BDA proposes to set up bodies at the national, state, and local levels, to carry out the above functions. Whether this Act will indeed help to protect agro-biodiversity and farmer community rights, only time will tell.

But by and large, the thrust of official agricultural research and development continues to be towards extensive monocultures, chemical use, and expensive inputs from sources outside the farming community. As mentioned above, the trend towards economic liberalisation in the 1990s has further intensified a destructive move towards commercialisation of agriculture. It is quite clear

that unless India's agricultural policy changes drastically, biodiversity and farmers' self-reliance will continue to be eroded.

Implications for agricultural policy and practice

The biggest question obviously is: can we feed a growing population with organic, biologically diverse agriculture? Alternatively, can farmers be given livelihood security through diversity? The examples mentioned above, as also many others in India, seem to indicate that there is great potential to increase and sustain food production through a mix of strategies based on revival of diversity. This relates not only to the use of traditional varieties which have shown high productivity, and of new varieties which build upon these without displacing them, but also to the use of agricultural systems which mix grain, fruit, nut, animal, and other sources of nutrition rather than concentrate only on grain production. Thus the rice and fish production system of the Apa Tanis of Arunachal Pradesh in north-east India or of farmers in Kerala in south-west India, or the baranaja system of the Garhwal Himalaya farmers, could provide models for sustainable, highly productive, agricultural techniques.

Based on the bitter lessons learnt from the Green Revolution experience so far, and the several positive experiments being conducted throughout India, some critical measures to achieve a biodiverse, productive, and self-reliant agricultural system can be delineated:

1. *Promoting a geographical mix of systems*: It is possible that the increasing need for foodgrains output may have to be met from conventional intensive farming, at least over the next few years when biodiverse farming is being revived or enhanced. This would probably be best done in irrigated plains, where grain productivity is already high, with care taken to minimise the use of fertilisers and pesticides. Simultaneously, a stress on biodiversity in the agriculture promoted in the hills, flood-plains, arid areas, and other 'marginal' areas, is absolutely necessary. Positive incentives would be necessary for this (see steps no. 7 and 10 below). Eventually, however, even the irrigated plains should move towards diversity and organic inputs, to become sustainable.

Promoting a mix also involves encouraging tree-crop, animal-crop, and tree-animal combinations, such as agro-forestry, fish-paddy cultivation, the Garhwali baranaja-bhimal system, and others. The productivity and need-fulfillment functions of these mixes are often much higher than the monocultures they are replaced with.

2. *Building on indigenous crop and livestock variety*, based on a thorough search for desired characteristics in this variety, including grain productivity, taste, smell, colour, drought and disease resistance, ability to grow in adverse conditions, efficiency in input use, fodder output, and others. In India, though

substantial work has been done along these lines, many traditional varieties are yet to be fully screened for their usefulness in specific conditions.

3. *The introduction of compulsory environmental impact assessment* (EIA) for agricultural projects. While EIA is now compulsory for most development projects like dams and industries, it is not yet geared towards looking at the impacts on agricultural biodiversity; in addition, many agricultural development projects are not subject to any EIA at all; finally, the process is not participatory. What is needed is a mandatory procedure in which the introduction of irrigation, new cropping patterns, HYVs, or any other agricultural changes is preceded by such an EIA, which involves the affected people as much as outside researchers. This will help to determine the potential loss of biodiversity, which would be an important part of deciding whether the project should go ahead at all or not; if it is decided to go ahead, such an assessment would help to determine the steps needed to minimise the loss.

4. *The encouragement of a diversity of food crops in the Public Distribution System*, including bajra, jowar, ramdana, and others. This will help to counter the bias towards wheat and rice in both domestic consumption, and in production. Indeed, a guaranteed off- take by the PDS of a diversity of cereals and other crops would be a major incentive for farmers to continue growing them. This will have to go hand-in-hand with public awareness campaigns promoting 'lesser' cereals as nutritional and tasty alternatives.

5. *Much greater involvement of women in decision-making* with regard to agriculture, from the individual field and village to national policies. It is women who conduct much of the harvesting, seed selection, sowing, storage, and other processes which conserve and enhance crop diversity, yet their role in decision-making is often marginal. It is well-known that women are far more reluctant than their menfolk, to let go of their traditional seeds and adapt new ones, because for them domestic consumption is more important than market profits.

6. *Reorientation of agricultural research and development (R&D)* from its current pre-occupation with a narrow definition of productivity, towards looking at rural systems in totality. Research must go much more into the total biomass production of a village ecosystem, including of tree- crop-animal systems, and of individual fields which are biodiverse vs. those which are monocultural; into multiple cropping systems like baranaja; into the revival and enhancement of indigenous crop varieties and livestock breeds; and into the various incentive systems which would encourage farmers towards biodiverse agriculture (see below, point 10). This will require changes in attitudes and programmes at the level of national agricultural research centres, agricultural universities, decentralised centres like the Nehru Krishi Vigyan Kendras (KVKs, or Agricultural Science Centres), and the agricultural

extension workers of the government. Some states like Andhra are experimenting with handing over KVKs to NGOs, with encouraging results.

In addition, R&D (including breeding) will have to become much more participatory. This does not mean that formal research centres will decide on research priorities and programmes, and merely ask farmers to participate; rather, it means that the agricultural R&D will emanate from the needs and opinions and knowledge of farmers, and its results will be tested and implemented by farmers, with the formal sector acting as a support structure. This is a radical shift in attitude and methodology, with modern agriculture scientists treating farmers as scientists and researchers in their own right, and working towards collaborative R&D (Sperling and Loevinsohn 1996). As the late rice expert Dr. Richharia stated: "It is vital that the application of science to rice agriculture and effective control of rice agriculture should remain in the hands of rice farmers..." (Indian Society for Rural Gene Banks 1992).

Finally, agricultural R&D must also learn from and integrate traditional Indian agricultural sciences. The Lok Swasthya Parampara Samvardhan Samithi, an all-India network of people and groups committed to the revival of local health care systems, has documented the enormous range of prescriptions that systems like Vrkshayurveda (plant science) and Mrgayurveda (animal science) had, many of which are relevant and useful even today. Equally important, these and other systems displayed a deep understanding of, and empathy with, the workings of nature, and built up elaborate theoretical foundations based on this (Banwari 1992; LSPSS 1990s). Their holistic approach is only now being approximated by modern ecology, trying to break away from the piece-meal approach of western science, which treats each subject as a separate entity as reducible to a few principles.

7. *Reorientation of the agricultural credit and subsidies system* towards encouraging biodiverse farming. Today's credit system, biased towards tractors and Green Revolution inputs, is a major disincentive for biodiverse agriculture. It must be completely reversed towards forms of farming which can combine diversity and productivity, and which help farmers to become as self-reliant as possible in the availability of essential inputs. The question of subsidies (e.g. on organic manure, indigenous seeds) is less clear, since over a long period, subsidies are not sustainable and do not encourage self-reliance. However, many small and marginal farmers may require some form of subsidies to help them switch over to organic farming, with the clear understanding that these are for a temporary period only.

8. *Strengthening the ex-situ collections with the aim of servicing in-situ cultivation*. While the gene banks of India hold considerable crop diversity, and have done a reasonably good job of collecting and preserving this diversity, they must now become actively associated with returning varieties to the communities from where they came, accompanied by appropriate educational

and material inputs which can help to revive their cultivation. Gene banks can also associate with movements like the Beej Bachao Andolan, in a search for varieties lost in the field, in returning varieties collected from their regions, in experimenting with these and other varieties in current in-situ conditions, and in encouraging community seed banks. It is important that this is done through appropriate agreements, which honour the intellectual and other rights of farmers who contribute to the process.

9. *Building up direct producer-consumer links*, between organic, biodiverse farmers and people who want wholesome food/products, as in the examples given above. More formal links than what has been tried so far, are still very tentative. Considerable work needs to be done on building up a responsive and cheap transporation arrangement, ensuring the availability of widespread distribution centres, quality control and certification, labeling and packaging, and other essential steps. However, it is clear that if these are taken care of (as they are for conventionally grown food), there will be substantial consumer demand for biodiverse organic food.

10. *Rewarding outstanding work in crop and livestock genetic resource conservation* and use in the informal sector (farmers, pastoralists). There is a strong case for positive incentives to farmers who have continued or innovated in biologically diverse farming, and pastoralists who have retained traditional or developed new livestock practices, as is the case in many of our marginal regions. These incentives could be both monetary and non-monetary (Gupta 1996; Kothari 1995), and would help to ensure that villagers do not switch to modern cash cropping or hybrid livestock, under the lure of superior (even if short-term) economic gains. If society is gaining from the in-situ conservation of agro-diversity, it should be prepared to reward/compensate the farmers whose fields and pastures are thus occupied. Interesting arguments for such a model have been made in the case of some of India's biosphere reserves, in which integration of natural and human-influenced habitats is the goal, and where it is recognised that the retention of many forms of traditional agriculture would be more conducive to wildlife conservation than modern commercial farming. Unfortunately, nowhere is this model yet in practice.

11. *Securing the common property and intellectual rights of farming communities*. Tenurial security to land and other resources is essential for farmers. In addition, it is unlikely that current models of intellectual property rights (IPRs), being heavily weighed in favour of private monopolies, are suitable. Indeed, it as has been argued persuasively by several experts, that such models could be disruptive of community systems, and that there are other viable alternative models which provide for much greater space to community-held resource and knowledge rights, while also allowing for individual innovations (GRAIN 1995; Nijar 1996; Shiva et.al.1997; Gene Campaign 1998; Posey 1996).

Special attention is needed in the case of migrant communities, such as nomadic pastoralists and shifting cultivators. Attempts to forcibly settle these people, or the impacts of development projects which have ignored their special needs, have severely disrupted their societies and practices. For their own sake and for the benefits that their knowledge and practices yield to larger society (see example of *kheri* sheep mentioned above), legal and administrative steps to safeguard their practices to the extent possible and to the extent they are environmentally sustainable, are urgently required.

12. *Strictly restricting the non-food cash cropping land* to a bare minimum. If even a part of the millions of hectares of land in India which are currently being used for tobacco, sugarcane, cotton, eucalyptus, tea, coffee, and other such monoculture plantations, could be converted back to food-growing lands, our foodgrains output would very quickly go up without having to pump in artificial inputs in intensively managed areas. This would of course, adversely affect our foreign exchange earnings, but surely local and national self-sufficiency is more important?

13. *Strictly limiting urban and industrial growth*, such that it does not eat up prime agricultural land, especially land where biodiversity has been retained or can partly be revived. For years the government has accepted the need for a land-use strategy which would help to regulate the diversion of agricultural land, but this is yet to be formulated and applied. Of course, many state governments have a law by which agricultural land cannot be given to non-agriculturists, but there are many loopholes in this, and the government often itself acquires the land for 'developmental' purposes. Recent moves to relax land ceiling and other regulations must be rolled back, or defeated through popular protest.

14. *Urgently identifying regions rich in traditional varieties and wild relatives of crops and livestock*, and conserving them. A commendable first step was taken several years back by the Meghalaya Government in India's north-east, by declaring a Citrus Sanctuary in the Garo Hills, an area rich in the wild relatives of citrus fruits (lemon, oranges, etc.), banana, and mango (Mehra and Arora 1982). Other state governments should follow suit. There may be hesitation in setting aside areas which could be converted to agricultural or industrial use, but consider this: a wild variety of rice, Oryza nivara, found in Uttar Pradesh, was able to provide genes resistant to one of paddy's most destructive pests, the brown planthopper, which had in 1974 destroyed more than 116,000 ha. of rice in Indonesia, India, Sri Lanka, Vietnam, and the Philippines (Prescott-Allen and Prescott-Allen 1983). Varieties using these genes are now grown over 30 million hectares in South and South-east Asia. If the area where the species was found had been "developed" for human use, we would have lost it forever. This is not an isolated example; as elaborated earlier, continued survival and enhancement of agriculture depends on the continued availability of wild relatives (and traditional varieties) of crops. For a start, India's declared

Biosphere Reserves, many of which contain a concentration of wild relatives, could become the focus of conservation programmes. One possibility is to declare them Biodiversity Heritage Sites under the proposed Biological Diversity Act (see Box 6).

15. *Educating decision-makers in the true value of agricultural diversity*, and in an expanded definition of productivity. This is indeed a major challenge, since the agricultural establishment is so tunnel-visioned that it can only see the artificially propped up productivity of grain (or milk, or wool, or other single products) as being the goal of Indian agriculture. To redefine the goal as one of meeting the total biomass and cultural requirements of the whole of society, and in particular of farming communities, would require a large effort in education. This effort must also include a true assessment of the value of traditional agro-diversity, wild relatives, and uncultivated species, using local farmers' own values as a base. Examples like that of *Oryza nivara*, given above, would help in providing a picture of their economic value, but emphasis must also be given to the social and cultural values that diversity provides.

Conclusion

The above steps are a distillation of lessons learnt from experiences of India's Green Revolution on the one hand and of India's organic farmers on the other. But though the answers are staring at us in the face, India's agricultural establishment is extremely slow to pay heed. This is understandable (though not justified), because the question of providing food security through biodiverse agriculture is ultimately related to larger economic and social issues: where and what kind of incentives and support measures can be devised for such agriculture, what kind of consumer demand can be generated for wholesome organic food, what land-and-water management systems can be evolved so that fertile agricultural lands are not sacrificed for urban or industrial use, how much we can reverse the trend towards converting food cropping lands to short-term cash cropping, and how we respond to the processes of globalisation.

In the final analysis, agricultural biodiversity can only be saved if the country's path of development undergoes fundamental changes. Currently, the development policies of countries like India appear to be heading further into the direction of destruction and unsustainability, fueled by its own internal contradictions and by being sucked into international homogenising forces like WTO. Unless the new economic policies and the proposed changes in legal regimes governing agriculture are challenged with united action and alternative visions, concerns related to biodiversity, sustainability, and equity will remain subordinated to the lure of profit.

It is in this context that the efforts of mass movements and activist groups gain critical importance. The Beej Bachao Andolan in the Himalaya, the farmers

movement in Karnataka represented by the Karnataka Rajya Ryoth Sangha (famous for its anti-Cargill demonstrations), the forces struggling against the new economic policies and against the imposition of the WTO regime in India (despite their tendency to exaggerate and distort the essentially destructive nature of these trends), and a host of other popular struggles are critical components of a move towards a more sustainable agricultural future.

In all this, even though their work is at a quiet and relatively undramatic scale, and will probably never make the morning headlines, it is the thousands of farmers and groups and communities who are reviving or experimenting with crop and livestock diversity, which are providing the final answer. There is no force more powerful than the one which asserts and ensures local self-sufficiency, and helps farmers to rid themselves of the debilitating dependence on industry-dominated markets and elite-dominated governments. That is the message that India's agricultural policy-makers must heed if they are to stop the country from going irretrievably down a suicidal path.

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Notes to readers

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