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Conserving India's Agro-Biodiversity: Prospects and Policy Implications

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Introduction

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

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 farmers' fields and pastoralists' pastures, and will this have an impact on the paramount goal of providing food 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 could at best supplement indigenous and local knowledge.

This paper attempts to:

- demonstrate the importance of biological diversity in Indian agriculture;
- analyse the crisis which Indian agriculture faces, especially in terms of the serious loss of biodiversity and farmers' self-reliance in the last few decades;
- examine the widespread efforts at reviving biologically diverse agricultural practices; and
- 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 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 has 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. At least 166 food/crop species and 320 wild relatives of crops have originated here (Dr RS Rana, pers. comm.).1 They 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 up to 200,000!) distinct varieties.2 One species of mango (Mangifera indica) has yielded over 1000 varieties, ranging from the size of a peanut to a musk melon; a similar figure is estimated in the case of taro (Colocasia esculenta).3

India also has amongst the world's largest diversity of domesticated animals, including some 26 breeds of cattle, 40 of sheep, 20 of goats, eight of camels, six of horses, and 18 of poultry (CSIR, 1970; Mohapatra and Panda, 1981; Khanna, 1993; and 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, 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 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 is 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 north-east 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 varieties (Richaria and Govindaswami, 1990).

Apart from physical and biological adaptation, a host of economic, cultural, religious, and survival factors have played a role in this diversification. 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 (Box 1).

Box 1. The 12 Grains System in the Garhwal Himalaya

The baranaja is a once-common practice of the Garhwal Himalaya. 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, Phaseolus mungo), mung (green gram, Phaseolus aureus), kulth (horsegram), marsha or ramdana (Amaranthus frumentaceous), mandua (finger millet, Eleusine coracana), jhangora (barnyard millet, Oplismenus frumentaceus), 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 is 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. 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).

The Erosion Of Agro-Biodiversity

Since traditional agricultural systems were finely interwoven with the social and cultural fabric of villages, 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 are offered related bank loans, to take enthusiastically to these varieties.

Agricultural schemes have also attempted to homogenise 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.

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). For example, 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 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. 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 an erosion in agricultural biodiversity include:

- 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.

- 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.

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

- 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.

- Changes in food habits; everywhere, people have been brainwashed into believing that wheat and rice are the only two cereals worth eating. This is made worse by the fact that 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 (PV Satheesh, pers. comm.). 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).

Why Does This Erosion Matter?

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

Firstly, it erodes the genetic base on which scientists depend 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.

Secondly, by opting for HYVs, the farmer becomes increasingly dependent on the industry-dominated market and the government. Virtually everything that is 'required' for farming, except land and family labour, is now obtained from outside the village: seeds, irrigation, fertilisers, pesticides, credit. And despite huge subsidies on these inputs, as well as 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 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).

Several other effects of modern farming have brought insecurity to the lives of farmers. For instance, the traditional paddy field in north-eastern, south-western, and central India provided not only rice but also fish, frogs, and other species 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 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.

The continued trend towards high-technology agriculture makes the country as a whole 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 sector is the first step towards this crippling dependence, and a direct reversal of policies which had, until recently, tried to take us towards self-reliance.

This process is likely to be greatly intensified with the implementation of the recently concluded General Agreement on Tariffs and Trade (GATT). This requires countries to greatly 'open up' their borders to both imports and exports, and substantially reduce governmental controls and interventions. A direct impact of this could be the easier entry of powerful multinational agribusiness corporations into Third World countries, corporations which would be able to push their crop and livestock varieties onto the farmer. Another impact will be the further commercialisation of agriculture, as the country pushes for greater agro-exports.

Furhermore, the provisons in the Trade-Related Intellectual Property Rights (TRIPs) part of GATT, especially those seeking to harmonise intellectual property rights (IPR) regimes across the globe and to enforce patentability of life forms, would force changes in the Indian Patent Act and related legislation. There could be severe implications for biodiversity. 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 varieties and further homogenisation would result. Additionally, innovations by farmers, which result in expanding diversity, may be hindered due to protection requirements which could become more and more stringent, as they have in many industrialised countries.

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, farmers experience considerable difficulty in accessing the genetic material, while 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, ie. on farmers' fields and 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 realising that a revival of the former 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, because the destruction of traditional diversity has not yet become irreversible. Consider the following facts:

1. The Green Revolution technology has not spread to many parts of the country, for several reasons, including its exhorbitant 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.

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 prefer to 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 the 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 not by any inherent characteristic of HYVs, but by an economic system which subsidises and favours these HYVs), with the personal desire to eat healthy food. Again, considerable on-farm diversity may exist because of this.

Recent Approaches to In-Situ Conservation in India

One exciting recent development is the deliberate attempt by groups and individual farmers to revive agricultural diversity (Box 2).

Box 2. The Revival Of Diversity

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.4 A few of the Andolan's members, small farmers like Vijay Jardhari and Raghu Jardhari, have been travelling 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 of about two acres: in all, he has tried about 130 varieties of rice, 110 varieties of beans, 40 of finger millets, eight 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), and so on.

Nor have these farmers restricted their activities to their own fields; they are actively which they have found useful for some characteristic or 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 whom 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.

This is taking root in many parts of India. 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.5

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 Biodiversity Registers which record the variety of uses that communities make of biological resources (Gadgil, 1996). These Registers are not only documented evidence of diversity, but also the means whereby communities can assert their rights to the knowledge and resources recorded therein, and crucial moral boosts to efforts which otherwise seem doomed in the face of the juggernaut of agricultural homogenisations (Box 3).

Box 3. Community Biodiversity Registers

Over the centuries, local communities have developed knowledge, skills, and techniques (KST) related to their biological resources. These knowledge systems have traditionnally been orally transmitted, and are not recorded. While this may have sufficed in earlier times, there appears to be 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 Biodiversity Register, which is aimed at documenting, at the village level, community KST of biological resources. The aims are multiple:

- revitalizing traditional knowledge/skills/techniques;
- protecting traditional/customary rights of local communities by providing proof of resource uses;
- assessing the economic value of community usage and conservation practices;

- priority setting for conserving those resources which are under threat;
- recognizing outstanding KST for rewards;
- sharing the local knowledge with other communities in India for mutual benefit; and
- protecting local KST 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, this draft format is being field tested in different 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. This exploratory exercise will provide inputs for suitably revising the format, so as to make it as widely applicable and comprehensive as possible. The Indian Ministry of Environment and Forests has been asked to assist in spreading it widely, including by publishing the Register format in regional languages, and providing the resulting documents a legal status so that it can be used in disputes over intellectual property rights and piracy of knowledge.

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 (Navdanya, 1993). These efforts have resulted in the documentation of several hundred varieties of rice, millets, and other crops in selected sites across different biogeographic regions of India (Shiva, et al., 1995).

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 persuading some consumers to search for organic food. 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.

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 a legislation on biodiversity, being formulated at the Union Ministry for Environment and Forests as a follow-up to the Convention on Biological Diversity, will also include measures to check the erosion of agricultural diversity.

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. Indeed, the trend towards economic liberalisation in the 1990s has further intensified a destructive move towards commercialisation of agriculture (Kothari, 1996). It is quite clear that unless India's agricultural policy changes drastically, biodiversity and farmers' self-reliance will continue to be eroded.

Implications For Policy And Practice

The biggest question obviously is: can we feed a growing population with biologically diverse agriculture? And can farmers achieve livelihood security through diversity? The examples mentioned above, as with many others in India, seem to indicate that there is great potential to increase and sustain food production through a mix of strategies to revive 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 evidence from throughout India, some critical measures to achieve a biodiverse, productive, and self-reliant agricultural system can be delineated in three main areas:

Research and Awareness Measures

- 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. More research is needed into the total biomass production of a village ecosystem; 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. Research and development needs to build much more on the many important characteristics contained within our crop and livestock diversity, 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.

- In addition, R&D (including breeding) will have to become much more participatory, so that priorities and strategies for research emanate from the needs, opinions and knowledge of farmers, and so that results are tested and implemented by farmers, with the formal sector acting as a support structure. This also recognises the need for much greater involvement of women in decision-making with regard to agriculture. 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 adopt new ones, because for them domestic consumption is more important than market profits. This reorientation of R&D 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 (Agricultural Science Centres), and the agricultural extension workers of the government.

It will be important to educate 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 tends to see only the artificially propped up productivity of grain as 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 non-cultivated species, using local farmers' own values as a base.

Development and Environment Policies

- Reorientation of the agricultural credit and subsidy system towards encouraging biodiverse farming. Today's credit system, biased towards tractors and Green Revolution inputs, is a major disincentive for biodiverse agriculture. Instead it could be reversed to support forms of farming which can combine diversity and productivity, and which help farmers to become as self-reliant as possible. The question of subsidies (eg. 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 subsidy to help them switch over to sustainable farming, with the clear understanding that these are for a temporary period only.

- There is a strong case for positive incentives to farmers engaged 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 (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. Special attention is needed in the case of migrant communities such as nomadic pastoralists and shifting cultivators.

- Tenurial and intellectual rights of farming communities need to be secured. It is unlikely that current models of intellectual property rights, being heavily weighted in favour of private monopolies, are suitable. Indeed, it has been argued persuasively by several experts that such models could disrupt community systems, and that there are other viable alternative models which provide for much greater space to community-held resource and knowledge rights (RAFI, 1989). For instance, the Working Group on Traditional Resource Rights has suggested Traditional Resource Rights as a bundle of rights which protect, conserve and compensate for the knowledge and resources of local communities (Posey, undated). The Third World Network has proposed a Community Intellectual Rights Act, which recognises the collective nature of knowledge, its past heritage and dynamic properties over time, and its usefulness not just for industrial purposes, but also for its social, ecological, and domestic values (Nijar, undated). In India, one way forward would be for the Community Biodiversity Registers (Box 3) being prepared to have a legal status, so that they both establish the claim of communities to prior knowledge, and also help to protect their knowledge against appropriation.

- Ex-situ collections need to be strengthened to service 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.

- Compulsory environmental impact assessment (EIA) is needed for agricultural projects. While EIA is now compulsory for most development projects like dams and industries, it is not yet geared towards looking at 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 process in which the introduction of irrigation, new cropping patterns, HYVs, or any other agricultural changes is preceded by an EIA, involving 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. In general, there should be strong restrictions on the spread of industrial and urban activities into agricultural land, and on the spread of food cash-cropping onto food growing lands, coupled with compensatory and incentive packages for farmers who may be affected.

- Regions rich in the wild relatives of crops and livestock need to be identified and conserved. 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. For a start, India's declared Biosphere Reserves, many of which contain a concentration of wild relatives, could become the focus of conservation programmes. 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. Biosphere Reserves would encourage the continuation of the activities of traditional communities in developing and using this agrodiversity.

Consumer Policies

- The encouragement of a diversity of food crops in the Public Distribution System, including bajra, jowar, ramdana, and others, 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.

- Direct producer-consumer links need to be built between sustainable, biodiverse farmers and people who want wholesome food/products, as in the examples given above. The development of more formal links than exist to date are still very tentative. Considerable work needs to be done on building up a responsive and cheap transportation arrangement, ensuring the availability of widespread distribution centres, quality control and certification, labelling and packaging, and other essential steps.

Conclusion

The above steps are a fairly common-sense distillation of lessons learnt from experiences of India's Green Revolution on the one hand and of India's sustainable farmers on the other. But though the answers are clear it is not so easy to implement them. 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 sustainably-grown 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 globalisation processes which demand standardised produce for ready-made markets.

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 which are reviving or experimenting with crop and livestock diversity, who 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, finally, is the message that the Beej Bachao Andloan and Navdanya and the ADS and others are giving and that Indian agricultiure must heed.

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