AGRICULTURE, BIODIVERSITY AND LIVELIHOODS: ISSUES AND ENTRY POINTS FOR DEVELOPMENT AGENCIES

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"There is no space for the myth that we must either choose the eradication of poverty or choose the environment. To work towards eradicating poverty we need to protect environmental resources. To protect those resources, we need to eradicate poverty."

Clare Short, 23 June 1997

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1. Agricultural biodiversity

1.1 What is agricultural biodiversity?

Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture: the variety and variability of plants, animals and micro-organisms at genetic, species and ecosystem level which are necessary to sustain key functions in the agro-ecosystem, its structures and processes[1].

Agricultural biodiversity is essential to the world for the following functions:

- sustainable production of food and other agricultural products, including providing the building blocks for the evolution or deliberate breeding of useful new crop varieties;
- biological support to production via, for example soil biota, pollinators, and predators;
- wider ecological services provided by agro-ecosystems, such as landscape protection, soil protection and health, water cycle and quality, air quality.

Local knowledge and culture can be considered as integral parts of agricultural biodiversity, because it is the human activity of agriculture which conserves this biodiversity[2]. Indeed, most crop plants have lost their original seed dispersal mechanisms as a result of domestication, and so can no longer thrive without human input. Domestication started 10,000 years ago and has been followed by natural selection through exposure to different climates, pests, pathogens and weeds; by human selection for specific traits and market needs, as well as for socio-economic reasons; and by wide dispersal. Crops and domestic animals are now found well beyond the limits of ecological tolerance of their immediate wild relatives, there is remarkable variability among and within crop landraces and animal breeds, and extraordinary ranges of adaptation. In the last 100 years, there has also been controlled plant and animal breeding by scientists which has allowed the recombination of diversity from widely different backgrounds, and the application of intense selection pressure.

In terms of biological taxa, agricultural biodiversity includes the following:

- Higher plants: crops; harvested and managed wild plants for food; trees on farms, pasture and rangeland species
- Higher animals: domestic animals; wild animals hunted for food etc; wild and farmed fish
- Arthropods: mostly insects including pollinators (e.g., bees, butterflies), pests (e.g., grasshoppers, greenflies), and predators (e.g., wasps, beetles), and insects involved in the soil cycle (notably termites)
- Other macro-organisms: e.g., earthworms
- Micro-organisms: e.g., rhizobia, fungi, disease-producing pathogens

More work has been done on major food and industrial crop genetic resources than on the other components of agricultural biodiversity. Inevitably, this paper reflects this focus, but these other components are also crucially important for sustainable agriculture. The biodiversity of insects, fish, forests, livestock and wildlife are also covered in other papers in this volume. Much of the work on plant genetic resources is summarised in the FAO report *The State of the World's Plant Genetic Resources for Food and Agriculture* (1998) (web.icppgr.fao.org) which provides a comprehensive assessment of the current conservation and use of plant genetic resources for food and agriculture (PGRFA).

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1 See CBD COP Decision V/5.
2 The information in this paragraph is taken from Lenné, 1999:2-4.

There are several distinctive features of agricultural biodiversity, compared to other components of biodiversity:

- agricultural biodiversity is **actively managed by farmers**;
- many components of agricultural biodiversity would not survive without this human interference; **indigenous knowledge and culture** are integral parts of agricultural biodiversity management;
- many economically important farming systems are based on 'alien' crop species introduced from elsewhere (for example, rubber production in South East Asia). This creates a **high degree of interdependence between countries** for the genetic resources on which our food systems are based;
- as regards crop diversity, **diversity within species is at least as important as diversity between species**;
- because of the degree of human management, **conservation of agricultural biodiversity in production systems is inherently linked to sustainable use** – preservation through protected areas is of less relevance;
- nonetheless, in industrial-type agricultural systems, **much crop diversity is now held ex-situ in gene banks or breeders' materials** rather than on-farm.

1.2 Components of agricultural biodiversity

1.2.1 Crop diversity[3]

Of the 270,000 species of higher plants, about 7,000 species are used in agriculture, but only three (wheat, rice and maize) provide half of the world's plant-derived calorie intake. A substantial share of energy intake is also provided by meat, which is ultimately derived from forage and rangeland plants.

Although world food production in the aggregate relies on few crop species, many more are important if production is disaggregated to regional, national or local levels. For example, in Central Africa cassava supplies over half of plant-derived energy intake, although at the global level the figure is only 1.6 per cent. Beans, plantain, groundnut, pigeon pea, lentils, cowpeas and yams are the dietary staples of millions of poor people. Within individual countries, aggregate food supplies may be secured from few crop species but staples such as oca, teff, fonio, and bambarra nut can be vital in particular local pockets. A large number of other crops may be important as suppliers of other significant components of diet such as protein, fats, vitamins and minerals. But, outside the communities concerned, there is a lack of knowledge about the diversity and distribution of less utilised food and agriculture species.

Genetic diversity (variation *within* species) is vital for the evolution of agricultural species, and their adaptation to particular environments through a mixture of natural and human selection. In crop agriculture, for some species this selection has led to the development of many thousands of 'landraces' or 'farmers' varieties'. The management of crop genetic resources is covered further in section 2 of this chapter.

1.2.2 'Wild' plant biodiversity

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3 The information in this section is taken from FAO, 1998.

In addition to domesticated plants, wild species are important nutritionally and culturally to many people. Foods from wild species form an integral part of the daily diets of many poor rural households and are especially important during the hungry season or famines. They are an important source of vitamins, minerals and other nutrients, and also represent ready sources of income for cash-poor households. In Tanzania in 1988, for example, it was calculated that the value of all wild plant resources to rural communities was more than 8 per cent of agricultural GDP. There are also wild relatives of crop plants which may supply useful genes through natural or artificial introgression. Neighbouring wild companion plants can harbour biocontrol agents useful in agriculture. Weed plants may be left to grow in fields in order to be harvested later for food.

The term ‘wild’ may be misleading because it implies the absence of human influence. Many plant populations that have been considered wild are actually carefully nurtured by people, albeit less intensively than those cultivated in their fields. Thus, there is no obvious or strict divide between ‘domesticated’ and ‘wild’ food species; rather it is a continuum according to the extent of human intervention.

1.2.3 Below-ground plant biodiversity[4]

Roots are responsible for nutrient and water uptake by crops. They physically stabilise soil structure against erosion and soil movement on steep slopes, and, in tropical systems, the contribution of roots to soil organic matter is proportionately larger than from above-ground inputs. The effects of roots on soil biophysical properties are particularly critical in impoverished farming systems where crop residues are at a premium for fuel and fodder. Paradoxically, there has been little attention to the selection of rooting traits in cultivars by crop breeders, and much less research into the production, turnover and structure of rooting systems in tropical crops than into the above-ground components they support.

In semi-arid regions, on soils of low inherent fertility, the phenology and distribution of roots determines water and nutrient availability for the crop during the growing season. Modern maize hybrids tend to show the rapid development of a large fine-root mass in topsoil which enables exploitation of superficial water and nutrients pools. As drought conditions develop surface rooting systems are progressively exposed to moisture stress resulting in a progressive uncoupling of surface nutrient pools and available water at greater soil depths. Under stressed conditions many smallholder farmers prefer to plant traditional land races, which are adapted to different soil niches and associated environmental conditions. The genetic determinants and phenological plasticity of root architecture in these landraces has not been systematically investigated and hence provide options for selective breeding and management.

1.2.4 Microbial biodiversity in agriculture[5]

Microbial biodiversity has been neglected over the years but is now a topic of global attention. This is due to the realisation that microbes contribute a wealth of gene pools that could be a source of material for transfer to plants to achieve traits such as stress tolerance and pest resistance, and large-scale production of plant metabolites.

Of more immediate significance to farmers’ production systems, microbes play varied roles in plant development and agriculture. Microbial interactions with plant communities range from disease-producing pathogens to associations with plant rhizosphere, phyllosphere and spermosphere as free living entities or in well-associated symbiotic associations for nitrogen

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4 Summarised from Professor J M Anderson, pers. comm. September 1998.
5 Summarised from Srinivasan (1998).

fixation or asmycorrhiza. Seed-borne microflora are instrumental in seed transmission of disease and thereby important in plant quarantine. Micro-organisms as food sources of ‘neutral insects’ support these alternative food sources of natural enemies of plant pests as described in the next section.

1.2.5 Arthropod biodiversity in agriculture

It is well known that insects, spiders and other arthropods often act as natural enemies of crop pests. But other components of arthropod diversity are also important in this respect. For example, research on Javanese rice fields has shown that arthropod communities are structured in such a way that the dynamics of seasonal succession consistently lead to high levels of pest suppression by natural enemies, with little chance of major pest outbreaks.

Control of plant pests by natural enemies is often considered inadequate due to seasonal oscillations in populations: the pest population peaks before that of the natural enemies. However, in the Javanese rice fields ‘neutral’ arthropods, mostly detritivores and plankton-feeders such as midges and mosquitoes, provide an alternative source of food for the natural enemies of rice plant pests, thus stabilising the populations of the natural enemies. In turn the detrivores are dependent on high levels of organic matter in the paddies which provides the food source for an array of micro-organisms (bacteria and phtytoplankton) and zooplantkton[6]. This emphasises the importance of soil organic matter levels as a source of food for insects which offer an alternative food source for the natural enemies of plant insect pests, thereby stabilising natural enemy populations even in the absence of the plant pest and/or its host plant.

As discussed further in the companion paper on insects, arthropods are also important as pollinators of many crops. Bees (of which there are several thousand species) and other pollinating insects are essential agents for the production of many crops, especially most major fruit and nut crops, many vegetable crops and a number of forage crops. Insect pollination is also required for seed production in crops such as soybean and sunflower. The estimated social worth of insect pollinators is of the order of several tens of billions of US dollars per annum[7].

1.2.6 Agricultural biodiversity and ecosystem functions

Historically, the focus in agricultural biodiversity work has been on characterising and conserving species and genetic diversity. Now, however, there is increasing realisation of the importance of agricultural biodiversity at the ecosystems level, consistent with the ‘ecosystem approach’ as promoted by the Convention on Biological Diversity[8].

An ecosystem consists of a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit[9]. Thus agro-ecosystems need to be considered at several levels or scales, for instance, a leaf, a plant, a field/crop/ herd/pond, a farming system, a land-use system or a watershed. These can be aggregated to form a hierarchy of agro-ecosystems. At a higher level still, the full assemblage of ecosystems constitutes the global biosphere. Ecological processes can also be identified at different levels and scales.

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6 Settle, et al. (1996) demonstrated this experimentally by manipulating organic matter levels.
7 Kenmore, et al. 1998, paper prepared for the CBD sponsored meeting on Pollinators, Brasilia, October 1998; extrapolated from data for the US.
8 See CBD COP Decision V/6
9 CBD, Article 2

Maintenance of agricultural biodiversity within the agro-ecosystem is necessary to ensure the continued supply of goods and services such as:

- evolution and crop improvement through plant breeding: it is now generally recognised that conservation off-site ('ex-situ') is only part of the action necessary to safeguard agricultural biodiversity for future evolution[10]. The interaction between the environment, genetic resources and management practices that occurs 'in-situ' within agro-ecosystems ensures that a dynamic portfolio of agricultural biodiversity is maintained and adaptable to changing conditions;
- biological support to production: is provided by the organisms that make up the biological diversity of the agro-ecosystem. As we saw earlier, earthworms and other soil fauna and microorganisms, together with the roots of plants and trees, ensure nutrient cycling; pests and diseases are kept in check by predators and disease control organisms, as well as by genetic resistances in crop plants themselves; and insect pollinators contribute to the cross-fertilisation of outcrossing crop plants. Agro-ecosystems vary in the extent that this biological support to production is replaced by external inputs: as we shall see in Section 1.3, in industrial-type agricultural systems, they have been replaced to quite a significant extent by inorganic fertilisers and chemical pesticides; but in the many areas, agricultural biodiversity remains a significant provider;

- wider ecological functions: valuable ecological processes that result from the interactions between species and between species and the environment include the maintenance of soil fertility, water quality and climate regulation (e.g. micro-climates caused by different types and density of vegetation).

This is sometimes referred to as 'functional agricultural biodiversity', i.e. that which is necessary to sustain the ecological function of the agro-ecosystem, its structures and processes in support of food production and food security. Focussing attention on functional agricultural biodiversity can be a useful way of prioritising effort. In the next Section, we explore the relationship between agricultural biodiversity and farmers' livelihood objectives under different natural and socio-economic circumstances. There is no such thing as an *a priori* 'optimum' level of agricultural biodiversity for an agro-ecosystem; rather, the desirable level is determined by the prevailing local, natural and – equally importantly – socio-economic circumstances[11].

1.3 Agricultural biodiversity in different agricultural systems

The mix of agricultural biodiversity in any one agro-ecosystem is determined by a matrix of 'human' factors and feedback loops in addition to the underlying natural conditions. The factors determining levels of agricultural biodiversity in production systems are:

- underlying ecological conditions;
- farmers' skills in on-farm agricultural biodiversity management (see section 2);
- farmers' access to useful agricultural biodiversity off-farm (neighbours, adjacent wild areas, formal sector plant breeders)[12] which is partly determined by connectedness,

[10] Conservation strategies are discussed further in Section 2.3.
[11] For more on the debate concerning ecological stability in agro-ecosystems and the contribution of agricultural biodiversity to this, see for example Conway (1997) and Thrupp (1998) versus Wood (1998).
[12] In this paper, 'formal sector' refers to scientifically-trained staff working in government, private, and voluntary sector institutions.

population pressure, communications, etc.;
- farmers' access to other capitals that can substitute for natural capital (for example, agro-chemicals), which is significantly determined by prevailing explicit and implicit subsidies.

We can distinguish between more 'traditional' and more 'industrial' agricultural systems, although in reality most agricultural systems contain a unique and complex mixture of both traditional and industrial components. Agricultural systems that are more 'traditional' can be characterised as being less integrated into the market network, because of lack of financial capital, or lack of infrastructure such as roads and selling points, and lack of access to relevant agricultural research and extension. Hence, farmers in traditional-type systems place less reliance for their livelihoods on selling produce, and less reliance on buying external inputs for agricultural production such as chemical fertilisers and agro-chemicals. Instead, they rely heavily on the available natural capital, in the form of quantity and quality of land, water resources, and agricultural biodiversity, to sustain their livelihoods. This includes, for example, the production of a wide range of food crops, fodder, medicine and building materials. Their emphasis may be on risk avoidance or minimisation, rather than on maximising production. This tends to produce a pattern of mixed farming in which a large number of species are cultivated, with considerable genetic diversity within species, and heavy use also made of wild plant diversity and non-plant agricultural biodiversity for both livelihoods and ecosystem functions and services. In more traditional-type agricultural systems, farmers actively manage agricultural biodiversity on-farm in order to improve productivity and maintain sustainability. The key requirement is to enable farmers to continue to do this.

In contrast, agricultural systems that are more 'industrial' are heavily integrated into the market system. Farmers produce largely for the market, and use the financial capital that is generated to fund investments in external inputs, as well as to provide other components of their livelihoods. The ability to realise a financial surplus may be the result of having access to a combination of abundant and productive natural capital, infrastructure such as product and capital markets, and human capital such as education and access to information. Their superior access to capital assets means that farmers in industrial systems are often relatively less dependent on natural capital, and can focus on maximising production rather than minimising risk. This tends to result in a pattern of monoculture, focusing on a few profitable species and varieties and relying on off-farm conservation and breeding. However, non-crop biodiversity (insect pollinators, soil micro-organisms) may remain high in these systems, which may furthermore benefit significantly from functions and services provided by off-farm agricultural biodiversity (for example, watershed protection), and are of course reliant on crop diversity held off-farm for continued crop improvement. More industrial-type agricultural systems are only sustainable if the accompanying infrastructure is available to support them: plant breeding capacity, roads, markets, etc.

People often think in terms of a simple correlation between agricultural zone, agricultural system, and levels of agricultural biodiversity, ie. that more traditional-type agricultural systems are found in 'lower potential' agricultural zones and are reliant on high agricultural biodiversity, whilst more industrial-type agricultural systems are found in 'higher potential' agricultural zones and are characterised by low agricultural biodiversity. As we shall see in Section 4, this generalisation obscures details which are very important in trying to identify the contribution of agricultural biodiversity to sustainable livelihoods across the spectra of agro-ecosystems.

2. The management of crop genetic resources

In more traditional-type agricultural systems, crop genetic resources, are, to a large extent maintained on-farm in a dynamic fashion. Crop varieties are often subject to constant influxes of genes from outside the farm, in the form of spontaneous introgression and deliberate importation of new material by farmers. The management of crop diversity in traditional-type agricultural systems is considered in Section 2.1.

In more industrial-type agricultural systems, on the other hand, much crop diversity is conserved off-farm in gene banks and manipulated off-farm by formal sector breeders. This requires a supporting infrastructure and attention to long-term conservation and base-broadening of genepools. The management of crop diversity by formal sector plant breeders is discussed in Section 2.2. Conservation of crop genetic resources is discussed in Section 2.3.

2.1 Farmer management of crop genetic resources[13]

Farmers view agricultural biodiversity from an agro-morphological viewpoint, using phenotypic characters as markers for taste, texture, yield, storage characters, resistance to environmental stresses, use and maturity time. Remarkable parallels exist across crops, cultures, and continents (Wood and Lenné, 1993). However, it is important to remember that farmers and communities vary in their capacity to manage agricultural biodiversity. Three factors strongly influence farmers' capacity: the existence and integrity of cultural diversity; access to genetic diversity; and the level of exposure to external influences such as agricultural modernisation or consumerist lifestyles.

Communities located in centres of plant genetic diversity that have managed local agricultural biodiversity for centuries with limited influence from outside developments, have a high capacity to manage agricultural biodiversity. Potato farmers in Cusco, Peru, for example, handle more than 150 varieties on their individual farms. Farmers in the highlands of Sierra Leone which have a strong cultural identity and a highly varied agro-ecology, experiment in order to develop desired plant characteristics of African rice. Farmers in Iringa, Tanzania, on the other hand, who have been exposed to agricultural modernisation and grow maize originating in other areas, no longer maintain local varieties in a pure form.

The capacity to manage agricultural biodiversity also varies considerably within communities and depends on the ethnic group, social status, gender relations and age of the farmer. Different social groups of farmers within a community may use different varieties of the same crop, each adapted to optimise performance under his or her respective resource constraints. In Zimbabwe, farmers who lack resources to prepare their land early in the season use a higher proportion of early maturing varieties than richer farmers. Some farmers can manage a higher than average number of varieties and risk experimenting with new germplasm or maintaining unusual varieties. Only the relatively better-off farmers in Usangu Plains in Tanzania, for example, cultivate a lower-yielding but particularly well-flavoured sorghum landrace.

There are also clear gender differences in local agricultural biodiversity management. Women are usually the seed selectors for the range of criteria required domestically by households, such as taste, colour, smell, cooking time, etc. Where a division of labour exists, women are often responsible for staple or subsistence crops and men for cash crops. Women's concern

[13] For more on this, see Bellon, 1996; Jarvis and Hodgkin, 1997; and, Cromwell and van Oosterhout, 2000.

with the household economy provides a balance to the market-oriented pressures that emphasise higher yield and uniformity. In many households, women manage components of the farming system containing high levels of biodiversity, such as home gardens, and make extensive use of gathered species and tree products. Since women often prepare family meals, this influences the variety of crops which they select for the home garden. Therefore, gender analysis is required to understand the dynamics of agricultural biodiversity management in a given household or community.

The biological features of different types of crops also influence farmers' ability to experiment with local plant genetic resources and to maintain landraces. While it is relatively easy for farmers to maintain a landrace population of a self-pollinated crop such as rice, it is more demanding to maintain a population of a cross-pollinating crop such as maize. Similarly, while it is relatively easy to experiment with landraces of vegetatively propagated crops, it is more difficult to maintain a high physiological quality of planting material of such crops, which tend to be affected by the accumulation of viruses and other pathogens.

The link between the effect of farmer management decisions and the amount of genetic variation within the crop population has not been studied in detail, but see Louette et al., 1996[14].

2.2 Formal sector plant breeding

Crop diversity is strongly influenced by formal sector plant breeding programmes. Over the years, such programmes have released a stream of new varieties of many crops, bred to increase yields in response to applications of chemical fertiliser; or which incorporate resistances to pests and diseases and thus reduce reliance on chemical pesticides; or other specific agronomic benefits. These new varieties (sometimes known as 'high-yielding varieties' or 'modern varieties') have contributed to large yield increases in many parts of the world, and have spread rapidly: in parts of Asia well over 80 per cent of wheat and rice land is planted to modern varieties. However, the widespread replacement of diverse varieties by a small number of homogeneous modern varieties, which was a feature of early formal plant breeding efforts, can lead to genetic vulnerability. This is the condition that results when a widely planted crop is uniformly susceptible to a pest, pathogen, or environmental hazard as a consequence of its genetic constitution. The results of this genetic vulnerability were well-documented in the US, Pakistan, Indonesia and many other countries in the 1960s and 1970s. Today, these risks still exist but formal plant breeders are more aware of them and can use various techniques to maintain more genetic heterogeneity in the varieties they release or to provide newer varieties rapidly enough to replace these becoming vulnerable.

African farmers have benefited less from the Green Revolution than farmers in Asia and Latin America. For some crops, such as wheat, rice, maize, and sorghum, this is because the new high potential yield varieties do not respond well to the more heterogeneous, low-input environment under which much farming takes place in Africa. For others, such as many African staple food security crops (e.g., millets, cassava, sweet potato, plantains), this is because comparatively less research effort has been invested for these crops in this region. As a result, FAO estimated that by the end of the 1980s less than 10 per cent of total cropped area in Africa was planted to new varieties.

Important factors influencing the impact of formal plant breeding on agricultural biodiversity include:

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14 Neither has there been much study of the impact of introgression between wild and domesticated species and how farmers and communities perceive these relations, but see Wilkes, 1977; Jarvis & Hodgkin, 1996.

- whether crop breeding is focussed on breeding for specific environments, where different varieties are adapted in each environment, or for wide adaptation where a small number of varieties occupy large areas. 'Specific' adaptation is particularly important for traditional-type agricultural systems. Fitting cultivars to an environment rather than the other way around is especially relevant where inputs are unavailable, too expensive or unprofitable due to a stressful and unpredictable environment;
- whether or not there is sufficient investment in ex-situ conservation and in broadening the genetic base of the material on which breeders work in developing new varieties in order to maintain some balance between adaptation and adaptability (for more on this, see Simmonds 1962; 1993);
- the extent to which simple single-gene traits are used; resistance to pests and diseases based on such approaches may often be particularly sensitive to breakdown.

In the future, new techniques in molecular biology, notably use of molecular markers for qualitative, polygenic traits, may contribute greatly to improving the efficiency of conventional plant breeding.

2.2.1 Gene transfer[15]

Gene transfer is another new technique, enabling the insertion of single genes or traits into breeders' existing gene pools. This can be used to transfer genes from virtually any species, whether plant, animal or bacteria, one of the much-publicised ones being *Bacillus thuringiensis* (*Bt*) which conveys some insect resistance. The products of these transfers between species are often referred to as genetically modified organisms (GMOs).

Gene transfer has potential benefits, for example in relation to incorporating new resistances to herbicides into crops, or to pests, thus reducing reliance on potentially dangerous and expensive pesticides. A recent CGIAR report (CGIAR, 1997) claims that transgenic crops could improve food yields by up to 25 per cent in the developing world and help to feed an additional 3 billion people over the next 30 years. Already in 1998, an estimated 28 million hectares worldwide were planted to transgenic crops.

However, in addition to the high cost of gene transfer, there are a number of other concerns:

- current techniques allow the transfer of single genes (although many energising techniques allow manipulation of qualitative traits controlled by multiple genes). As is apparent already from conventional plant breeding work, single-gene resistances to pests and diseases are often race-specific and sooner or later are overcome through evolution of the pest or disease organism;
- the possibility of transfer of the introduced trait to weedy relatives etc. This risk exists in conventional plant breeding but is a particular concern in the case of herbicide-tolerant crops;
- the large scale use of introduced traits for toxins such as those from Bt may have a negative impact on biocontrol agents and soil organisms;
- corporate control of agriculture. The new gene transfer technologies have produced a number of mergers and takeovers between seed and chemical companies. Because of the high investment required, these super-companies have attempted to exercise exceptional control over the technology – through patents, and the so-called 'terminator technology' (a genetic mechanism rendering a crop's progeny infertile) – which limits farmers' capacities to save or trade seed of protected varieties.

15 For more on this see Tripp, 1999.

The Cartagena Protocol on Biosafety, negotiated under the Convention on Biological Diversity provides a global regulatory framework for the transboundary transfer of transgenic crops .

2.3 Genetic erosion and conservation of agricultural biodiversity

Whether the introduction of new genetic material – be it modern varieties, farmers' varieties, or by natural introgression – actually results in increasing or decreasing agricultural biodiversity on-farm will depend on:

- is the new germplasm added to the farmer's portfolio or does it replace existing germplasm?
- is the new germplasm uniform or heterogeneous?
- is it from a fixed or segregating population?

Also, the environmental, economic, and social dynamics outlined so far have different effects at field, farm, village, national, and global level. Some may have positive effects at one level but negative effects at another. Thus, the effects on agricultural biodiversity of these change processes are difficult to predict. For example, in the case of crop diversity, decentralised plant breeding might, in some cases, lead to fewer varieties per farm. But if the result on each farm is different (because of specific adaptation during selection to the different environments and differences in farmer preference), then agricultural biodiversity may be maintained or enhanced when analysed at higher levels of aggregation.

Furthermore, changes in agricultural biodiversity are difficult to measure at the genetic level. The most common means of assessing erosion in farm level crop diversity is by counting named varieties, but this is different from actual genetic erosion because variety names do not necessarily correspond to cultivars/genetic content either geographically or over time. Better methods of assessment are required.

Nonetheless, it appears that agricultural biodiversity is being eroded and the accompanying local knowledge of food producers is also under threat[16]. In traditional-type agricultural systems, the main risk to agricultural biodiversity is from desertification, environmental degradation, and to some extent from species and varietal replacement. In industrial-type agricultural systems, there is a high risk of genetic erosion on-farm through simplification of ecosystems, and species and varietal replacement. Everywhere, the genetic erosion of agricultural biodiversity is also exacerbated by the loss of forest cover, coastal wetlands and other 'wild' uncultivated areas. This leads to losses of wild relatives and losses of the wild foods that are essential for food provision.

As regards plant diversity, up until the last decade or so, international scientists generally believed that the best way to conserve plant diversity was to collect samples from farmers' fields and preserve these in national and international 'gene banks'. However, for various reasons it is now widely accepted that ex-situ conservation should be complemented by in-situ or on-farm conservation, that is, conservation through sustainable use in farmers' fields. In-situ conservation is promoted in the *Convention on Biological Diversity*, and also forms a significant part of the *Global Plan of Action for the Conservation and Sustainable Use of PGRFA*.

Proponents of this approach point out that the dynamism which makes on-farm conservation difficult to 'manage' conventionally is an essential part of the conservation process, whilst also

16 See Thrupp, 1998: 22–30 for evidence of loss of genetic diversity and habitat diversity in global agriculture.

recognising that on-farm conservation is a complement rather than a substitute for existing ex-situ methods. Farmers' interest and skills in on-farm conservation are now beginning to be documented[17], and, as we shall see in Section 5, there are various ways of creating an enabling environment for on-farm conservation. Indeed, most recently, it has been recognised that in-situ or on-farm conservation should take into consideration the whole ecological system which is being cultivated since agricultural biodiversity includes not only genetic and species diversity but also diversity in ecosystems as a whole[18]

17 See, for example, Altieri and Merrick, 1987; Bellon, 1996; Louette et al., 1996; Cromwell and van Oosterhout, 2000.

18 For more on the ecosystems approach, see FAO, 1999.

3. The values of agricultural biodiversity and who benefits

3.1 The goods and services provided by agricultural biodiversity

Agricultural biodiversity provides many goods and services of environmental, economic and social importance (see table 3.1) and makes important contributions to sustainable livelihoods in a number of ways:

- agricultural biodiversity contributes directly to sustainable livelihoods in both traditional and industrial-type agricultural systems through production effects (crops, soil nutrient recycling, pest predators, etc);
- it also contributes to sustainable livelihoods in traditional and industrial-type agricultural systems through the provision of important ecosystem functions and services; and,
- it contributes to the livelihoods of a wide range of other stakeholders (public sector plant breeders and other agricultural research scientists, international biochemical companies, urban consumers in the North and South, the international gene bank system; see box 3.1).

We need to take an integrated approach to analysing the contribution of agricultural biodiversity to sustainable livelihoods because of the significant spillover effects and feedback loops that operate. For example, areas of high agricultural biodiversity may provide environmental services needed to sustain monocultures in neighbouring industrial-type agricultural systems.

Figure 3.1 adapts the sustainable livelihoods framework described in Carney (1998) to summarise some of the key features of the relationship between agricultural biodiversity and sustainable livelihoods

As regards the feedback loops, remember that agricultural biodiversity assets are significantly affected by natural conditions and processes of evolution, as well as by production, consumption, conservation, and human components of the vulnerability context and transforming structures and processes.

Table 3.1 sets out a typology of the ways in which agricultural biodiversity contributes to the livelihoods of different stakeholders. Opportunities for supporting these livelihoods are outlined in Section 4.2 and Section 5.

[NB Figure 3.1 should appear AFTER Table 3.1 and Box 3.1]

Figure 3.1 Agricultural biodiversity & sustainable livelihoods: a framework

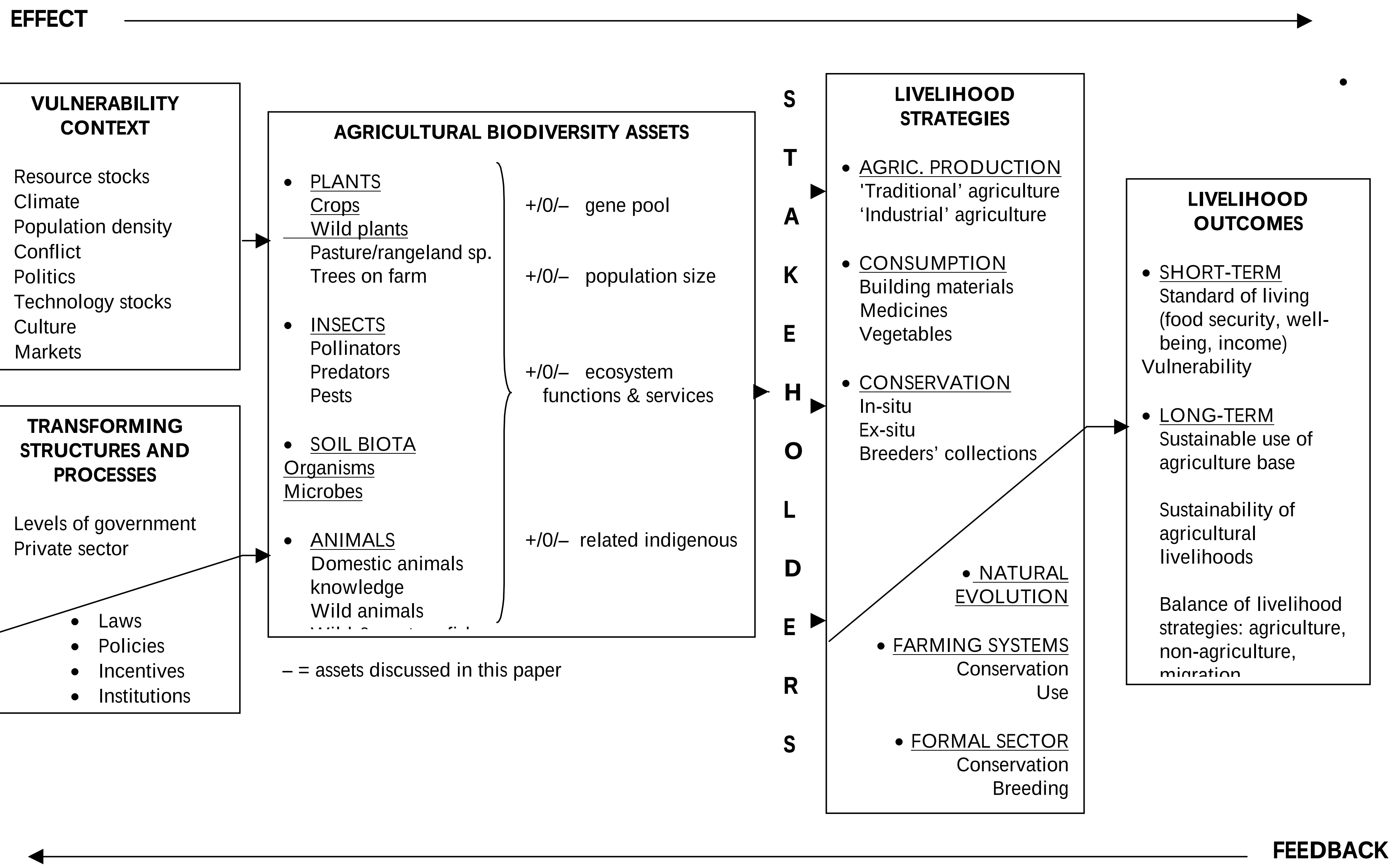


Table 3.1 Goods and services provided by agricultural biodiversity

Goods and services	**Examples**	**Nature of value**	**Contributions to livelihoods and benefits to other stakeholders**	**Major challenge for sustainability of use**
Goods				
1: Products derived directly from biological resources hunted or gathered from natural or semi-natural systems	Most fish, wildlife, gathered wild foods and medicinal plants etc.	Direct use values (consumptive, much not traded in markets)	Significant contribution to nutrition and other livelihood needs of rural and peri-urban vulnerable groups, and of traditional healers	To avoid over-exploitation of resources
2: Products derived directly from biological resources hunted or gathered from managed systems through agriculture	Crop and livestock production, timber from plantation forestry, and fish from aquaculture	Direct use values (consumptive, some not traded in markets)	Basis of sustainable food production and livelihood systems, especially for traditional farmers. Basis of food industry	To ensure sustainability of the managed ecosystem itself (see item 4 below); To avoid negative externalities on other ecosystems
3: Products derived indirectly (i.e. from the information content) of collected genetic resources	Pharmaceutical derivatives and new plant varieties	Direct use value (current use) Option value (known material, not used currently) Exploration value (undiscovered sources)	Raw material for plant breeding and pharmaceutical production. Values largely appropriated by breeding and pharmaceutical companies, and by farmers in 'industrial' areas who use improved varieties	To ensure continued provision of genetic resources by incentives and fair and equitable sharing of benefits derived.
Services				
4: Essential processes to ensure continued functioning, resilience and productivity of ecosystems which provide the goods 1, 2 and 3	Nutrient cycling, pest and disease control, pollination	Indirect use values	Essential support to sustainable food production and livelihood systems for all types of farmers. Benefits largely appropriated at local level.	To maintain ecosystem integrity; to prevent pollution
5: Wider ecosystem functions	Watershed protection, carbon sequestration, habitat protection	Indirect use values	Benefits of services appropriated at various levels, from local to global.	To maintain ecosystem integrity; to prevent pollution and habitat conversion. To internalise externalities.
6: Cultural and aesthetic functions	Scenic landscapes; species (esp. of charismatic animals), crop varieties of cultural importance	Direct use value (recreation), Indirect use value, Existence Value	Benefits of services appropriated at various levels, from local to global.	To prevent damage from excessive or inappropriate tourism; prevention of habitat conversion

Goods and services	Examples	Nature of value	Contributions to livelihoods and benefits to other stakeholders	Major challenge for sustainability of use
7: Insurance against risk and uncertainty	Use of multiple species, breeds and varieties	Portfolio value Option and Exploration values	Portfolio value appropriated at various levels, from local to global. Option and Exploration values mostly appropriated at global level, as per good #3.	To maintain incentives for their use and conservation

Box 3.1 Stakeholder groups

Direct stakeholders: There are seven main groups with a direct stake in agricultural biodiversity:

- **Multinational companies**, including a range of agro-chemical, food and medical companies in developing and developed countries. Their main objective is to profit from using agricultural biodiversity. This means they are often keen to protect the return on their investments in research and development through expanding intellectual property protection or technology that confers similar protection (e.g. terminator technology). They are also concerned to ensure their continued access to agricultural biodiversity in-situ.
- **Consumers**, in the North and South, of fresh and processed food, and medicines, demand accessible, cheap, safe and, increasingly environmentally-friendly products. In the North, the latter two concerns are leading to a growing market for organic food that is grown under systems which document and minimise environmental impacts. This can conflict with the desire for accessibility and low cost, as these are more easily met by international food companies producing uniform products. As well as valuing biodiverse agricultural landscapes for leisure and aesthetic purposes, consumers also increasingly recognise the existence value of agricultural biodiversity. Communities in the South may also place a high value on agricultural biodiversity for cultural reasons.
- **Scientists**, including plant breeders, pathologists, environmental scientists and also food technologists and medical researchers. Scientists involved in basic research may be primarily motivated by scientific enquiry and their main concern in relation to agricultural biodiversity is likely to be to maintain open access and freedom of exchange. Those developing near-market technologies, such as plant breeders, food technologists and medical researchers, may be concerned with capturing some of the financial rewards of their work.
- **International gene bank system**, including national/regional, private sector and CGIAR gene banks. The Consultative Group on International Agricultural Research has 50 governments as members and, in its network of international centres, holds the world's largest ex-situ collection of germplasm. This group aims to maintain continued freedom of access and exchange, whilst recognising the need to better document and acknowledge the contribution of farmers.
- **Farmers in industrial-type agriculture**. Farmers are the traditional conservers and improvers of agricultural biodiversity and ultimate recipients of formal sector improvement efforts. However, farmers in industrial-type agriculture have possibly not historically recognised the value of agricultural biodiversity on-farm, believing that agricultural biodiversity primarily relates to crop diversity, which is conserved and managed off-farm. Nonetheless, they are highly reliant on agricultural biodiversity for new crop varieties, pollination and pest and disease control, maintenance of soil health, and ecosystem functions. Given that global food security depends significantly on production in industrial-type agricultural systems, it is relevant to note the important contribution of agricultural biodiversity to global food production as well as to sustainable livelihoods in rural areas.
- **Farmers in traditional-type agriculture**, including a variety of large and small farmers, men and women, in different ecological zones, who value agricultural biodiversity in different ways. Providing adaptation to lower input conditions is particularly important for poorer farmers in traditional-type agriculture who cannot afford expensive external inputs. In providing specific adaptation, agricultural biodiversity is valuable both for individual farmers in coping with environmental variation on-farm and in more aggregate terms in coping with the significant environmental variation that exists at agro-ecosystem level in traditional-type agriculture. This is because it leads to higher total biomass production in diverse environments, such as typically exist in traditional-type agriculture, where individual varieties may not be well-adapted to the full range of conditions experienced. In creating the potential for high biological production, agricultural biodiversity is relevant to farmers in both traditional- and industrial-type agriculture. In providing a range of nutritional inputs, agricultural biodiversity is particularly valued by women as food providers, even though this value may be ignored by other members of the community who are more concerned with total grain yield, and/or by conventional agricultural research and extension for the same reasons. In addition to these values which are captured by individual farmers, agricultural biodiversity also provides more general benefits in terms of fulfilling important functions in the wider agro-ecosystem, such as nutrient cycling, pest and disease control, introgression, and watershed protection
- **Providers and users of traditional medicine** may place a high value on certain roots, wild plants, extracts, etc. Although traditional medicine is experiencing a resurgence in the South, partly in response to the increasing cost of conventional medical services following economic reform, few providers have secure access and rights to the agricultural biodiversity they may wish to use. There is little information available on access and rights in traditional medicine in the North.

Indirect stakeholders:

- **Countries and country groupings** hoping to capture some of the value of agricultural biodiversity managed and maintained by their citizens through the provisions of international agreements such as CBD and TRIPs. Country aggregations include: EU, ASEAN, Andean Pact, Nordic Group, G-7 and G-77. The level of government receptivity to the principles of sustainable use and equitable benefit-sharing for agricultural biodiversity varies.

- **NGOs and CSOs** hoping to capture for their members, or assist the capture of, the value of agricultural biodiversity and to maintain free access.
- **Multilateral and bilateral donor organisations** who directly or indirectly fund the protection and exploitation of agricultural biodiversity.

3.2 Identifying agricultural biodiversity values[19]

Economists identify various categories of the values of agricultural biodiversity (see also Table 3.1). However, the economic valuation of many aspects of agricultural biodiversity remains problematic.

Direct uses of agricultural biodiversity include a range of products which provide dietary diversity and make important nutritional contributions (provision of minerals, vitamins and protein; hunger crops). They include:

- *Consumptive* uses: goods that do not appear in national economic statistics, but which local people need (e.g. medicinal plants, wild vegetables, building materials), can be valued at the cost of market alternatives.
- *Productive* uses (goods sold in commercial markets) are conventionally valued at the net price at the point of sale.

Additionally crop diversity can generate improvements in yields through plant breeding. For example, genetic improvements in US crops were responsible for increasing the value of the harvest by an average of $1 billion per year from 1930 to 1980 (Primack, 1993).

Indirect uses of agricultural biodiversity include production effects such as adaptation to lower input conditions; specific adaptation (intra-farm and inter-farm); reduction of risk; potential for high biological production; and having a range of varieties and species with complementary agro- ecological requirements. Swanson et al., (1993) also identify the 'portfolio value' of agricultural biodiversity whereby losses due to the failure of a particular crop or variety are compensated for by the yield of other crops and varieties.

Indirect uses also include ecosystem services: biodiverse agriculture provides more of these important services than does monoculture. Some ecosystem services can be valued relatively straightforwardly, for example wild insects pollinating crops can be valued at the incremental value of the crop, or the cost of hiring honey bees. Others, such as CO2 absorption by plant communities, are much harder. However, the value of these services is rarely captured in a market. Indeed, the value of ecosystem services is inadequately captured using conventional economic analysis, as we shall see below.

The `option' value of biodiversity is the potential of agricultural biodiversity to provide economic benefit to human society in the future. Swanson et al., (ibid) identify two components of this:

- *Insurance value*: insurance against future adverse conditions, as needs are constantly changing and because genetic resources may later prove to provide useful characteristics, for example resistance to new diseases or adaptability to changed climatic conditions; and
- *Exploration value*: agricultural biodiversity represents a treasure chest of potentially valuable but as yet unknown resources.

[19] Adapted from Primack, 1993 and Swanson et al., 1993.

'Non-use' values include the *Existence value* (for biological communities, or areas of scenic beauty) This is often valued in crude terms at the amount people are willing to pay to prevent a species from going extinct or an area being developed.

3.3 Appropriation of the values of agricultural biodiversity

The values of agricultural biodiversity are often not completely captured by the relevant stakeholders, which has important implications for agricultural biodiversity conservation and use:

- some values of agricultural biodiversity are realised at **higher levels of aggregation** – for example, the value for reducing variability in food yields and thus prices world-wide is felt on global markets, not by individual farmers. This limits the incentives provided to individual farmers or national governments to invest in agricultural biodiversity conservation;

- values such as 'exploration value' and 'option value' are usually public goods under current institutional arrangements. This means that, although they may provide benefits to certain groups, these benefits are not fully appropriable under existing property rights systems. The exception to this being where exclusive bio-prospecting rights are granted, but this usually applies to medicinal plants rather than agricultural crops;

- much of the value of agricultural biodiversity is not divisible. This means that, although different groups of stakeholders have contributed to agricultural biodiversity management and development, and should therefore each receive a share of the benefit, in practice some groups are better able to appropriate a large share of the benefit for themselves.

To date, stakeholders who use agricultural biodiversity directly, such as farmers in both traditional and industrial-type agriculture, and providers and users of traditional medicine, have been weaker in terms of voice and market power compared to those with an interest in controlling access to it. The emergence of a strong private sector in the shape of international agro-chemical companies has greatly complicated matters. The private sector demands effective intellectual property protection before investing in technology development, so the technologies and knowledge produced by the private sector are no longer public goods. On the other hand some of the goods and services provided by agricultural biodiversity, such as most ecosystem functions, will always remain public goods; and incentives or public support may be required to ensure the continued provision of these positive externalities.

Overall, there have been powerful forces pushing for a reduction in agricultural biodiversity on-farm, through the promotion of chemical fertilisers, uniform crops and varieties, etc. This tendency may be strengthened by increasing consolidation in the 'life science' industry and the acquisition of seed companies by chemical companies. On the other hand, there are also some countervailing changes:

- the end to the global system of agricultural subsidies promoting industrial-type agriculture (through the current WTO negotiations, etc) is leading to the development of new agricultural practices and technologies that may be more biodiversity-friendly;
- the increasing voice of consumers demanding ecologically-friendly agricultural production processes;
- the increasing voice of farmers' and civil society organisations;
- the increasing recognition of cultural values and indigenous technical knowledge in important international treaties such as the Convention on Biological Diversity;

- the increase in the number of international treaties and agreements promoting conservation, sustainable use and benefit-sharing in agricultural biodiversity.

This analysis of agricultural biodiversity points to the inevitability of conflicts between the vastly differing interests of diverse stakeholders in agricultural biodiversity, exacerbated by their dramatically different degrees of effective voice and market power. This points towards the importance of treaties for reaching agreement on agricultural biodiversity issues, as well as institutions for effective management, at the local, national and international levels. There is a need to promote mechanisms that return a fair proportion of the benefits to the stakeholders who manage agricultural biodiversity at the local level. Additionally, non-market uses of agricultural biodiversity (for example, the provision of ecosystem services and functions) require public support to ensure their continued provision.

4. Agricultural biodiversity, poverty and development

4.1 Agricultural biodiversity, conversion and poverty

There are two key questions in the agricultural biodiversity debate: what is the relationship between agricultural biodiversity and poverty; and, why do people still convert to lower agricultural biodiversity livelihood strategies despite all the supposed benefits of maintaining agricultural biodiversity?

There is some evidence that agricultural biodiversity – particularly plant diversity – is concentrated in areas of poverty: in general, there is more plant diversity in developing countries than in developed countries; further, plant diversity tends be concentrated in the poorest, least developed regions of countries. This has led to a view that development and agricultural biodiversity are in opposition, and that economic development should involve the 'conversion' of diverse areas to 'more productive' areas. But this is an over-simplification of the issue in at least three respects:

- it is difficult to compare agricultural biodiversity across zones, because levels of diversity are different for different sub-sets of agricultural biodiversity in different agro-ecological zones, eg, in intensive rice systems of South and South-East Asia, crop diversity is relatively low but non-crop biodiversity can be high;
- agricultural biodiversity is essential for rich countries and industrial-type agriculture for continued evolution and agricultural improvement, although it is no longer usually maintained on-farm in these areas;
- the relationship between agricultural biodiversity and poverty at the micro level is not clear cut, as is explained in the following paragraphs.

Closer examination of many 'less developed' areas with biodiverse agricultural systems shows that farmers often choose to maintain local crop germplasm because in these areas, and under current economic conditions, it spreads the risk better than the alternatives from formal sector plant breeding.

However, there are important variations in different households' dependence on agricultural biodiversity within communities. On the one hand, researchers have found that within any given community, crop diversity is often handled more by richer farmers (for example, Cromwell and van Oosterhout, 2000; Brush, 1988). On the other hand, there are also clear cases where poor or vulnerable groups are highly dependent on other aspects of agricultural biodiversity (minor crops, wild plants, soil biota, insects) and may maintain it more carefully. These groups are often directly dependent on agricultural biodiversity for both on- and off-farm livelihood activities. Loss of this biodiversity can be associated with heavy livelihood losses through undermining their production choices, food security, and increasing their exposure to risk.

Thus, the correlation between agricultural biodiversity and poverty does not indicate a causal relationship, only that a location-specific approach to development is required. Ultimately, the most appropriate blend of agricultural biodiversity in farmers' portfolios depends on the precise local context. Hence, there is a need to work with local farmers and communities in a participatory manner to identify opportunities for action and the most appropriate means of implementation.

Undoubtedly, agricultural biodiversity is decreasing world-wide due to the combined effects of what Swanson et al. (1993) call 'specialisation, harmonisation and homogenisation' – all components of globalisation. Conversion for economic gain is a fact in both traditional and industrial-type agricultural systems. People still convert in traditional-type agricultural systems to lower agricultural biodiversity livelihood strategies due, amongst other causes, to prevailing economic distortions which are institutionalised in the current global economic system. These include, for example, input subsidies, agricultural extension messages, or widespread distribution of modern seeds in emergency relief packages. For politically, economically and socially marginalised groups, protection, maintenance of, and improved access to, agricultural biodiversity can often contribute more to sustainable livelihoods than conversion, as their traditional entitlements to agricultural biodiversity may be stronger than their market access to agricultural production inputs. Note however that there are often good reasons for adding some new genetic material to farmers' variety portfolios, to fill particular niches (storability, taste, etc) or to cope with change in the agro-ecosystem (e.g. climate change requiring shorter-duration materials).

It is therefore highly inappropriate to promote large-scale abandonment of biodiverse agriculture. But the challenge is to create a new enabling environment that makes returns to the maintenance of agricultural biodiversity more sustainable and more accurately reflect agricultural biodiversity's true value to the livelihoods of different stakeholders.

4.2. Opportunities for using agricultural biodiversity to reduce poverty

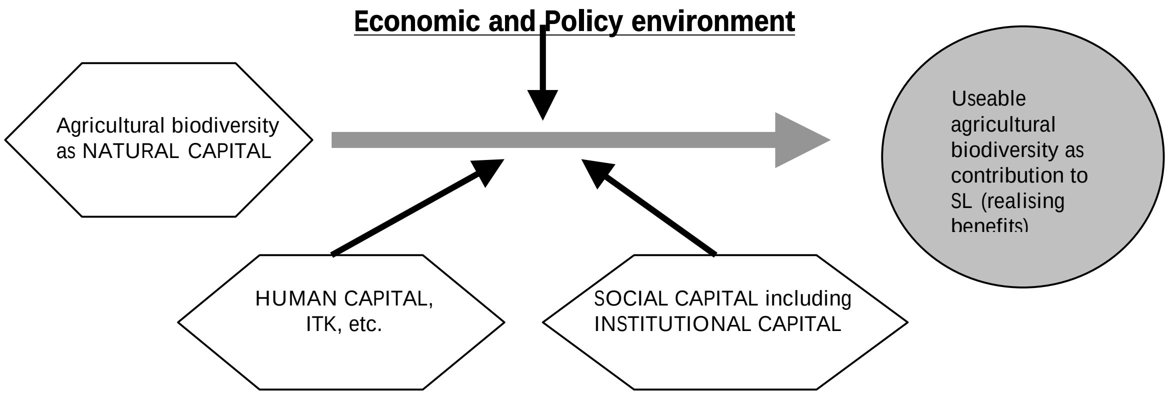
A new approach to agricultural biodiversity is needed (see Figure 4.2), in which local, national and global action contribute to the management of agricultural biodiversity. This involves:

- cross-sectoral action (agricultural biodiversity issues have relevance beyond natural resources management);
- a combination of policy and area-based approaches;
- a decentralised knowledge-intensive approach to technology development where farmers are full participants in the process;
- strengthening of local institutions;
- a high degree of policy input into arrangements for managing and sharing agricultural biodiversity because of the significant differences in agricultural biodiversity between people, countries, and regions.

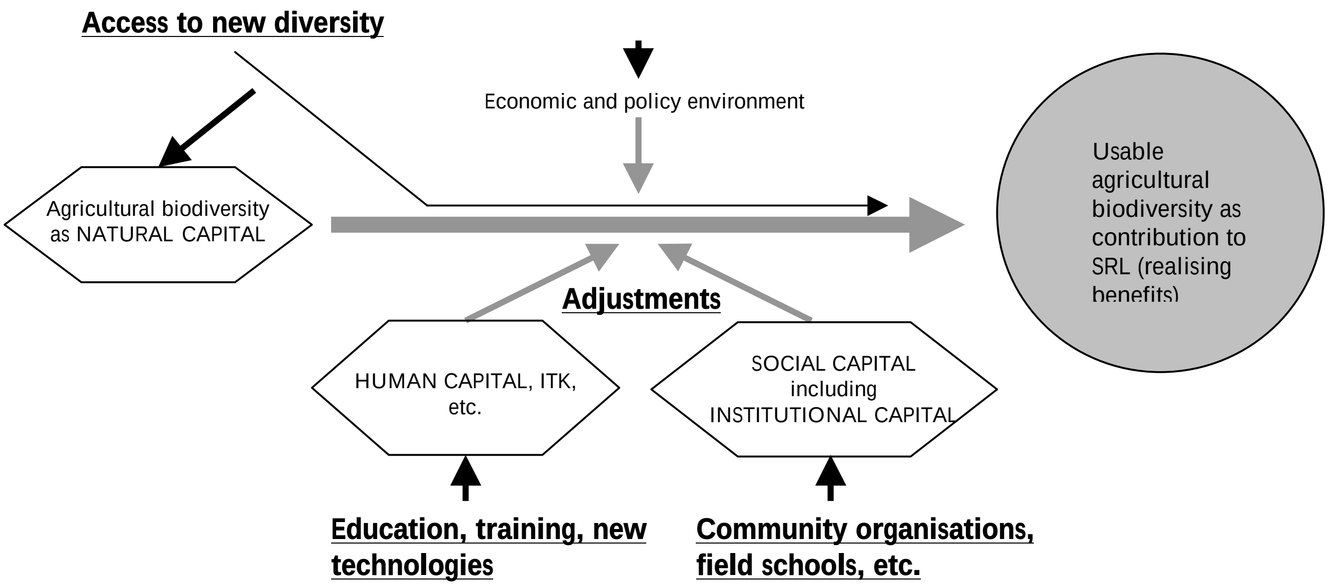
It is essential to change the economic incentives, and institutional and policy barriers that currently discourage the sustainable use of agricultural biodiversity. It is also essential to correct the current policy, research and implementation activities which subsidise the replacement of goods and services provided by agricultural biodiversity by external inputs, and thereby create an inertia reinforcing the industrial-type agriculture model. Agricultural biodiversity is often viewed as a resource stock that can be drawn down in order to contribute to strengthening people's livelihoods, but in reality it is more of a dynamic system than a stock. Agricultural biodiversity has social and economic as well as environmental and biological components, and is subject to human as well as natural selection pressures. Therefore, although it is often regarded as part of 'natural capital', in fact it also has important components of 'human capital'.

Figure 4.1: A framework for using agricultural biodiversity to support sustainable rural livelihoods.

1 The main objective: to use agricultural biodiversity to contribute to sustainable livelihoods



2 Human capital and social capital allow agricultural biodiversity (natural capital) to be used and thus to contribute to SLs. This is in context of policy and economic environment. Physical and financial capital may also be important, but are not shown here for



3 Entry points to strengthen ability to use agricultural biodiversity might include: access to new biodiversity; education, training and access to new technologies, and strengthening of village and farm organisations as well as adjustments to economic and policy environment.

Earlier sections have demonstrated the role of traditional-type agricultural systems and technologies in managing agricultural biodiversity. Care should be taken not to undermine these traditional approaches nor to sweep away unnecessarily the agricultural biodiversity on which they are based. But a purely conservationist approach must also be avoided. Farmers in traditional systems, just as much as those in industrial farming systems, need access to modern varieties as well as to farmers' varieties, and to the whole range of genetic material in between.

At the **local level**, it is important to remember that different agro-ecosystems may require different approaches. In *traditional-type agriculture*, the aim is to maximise the contribution of agricultural biodiversity to sustainable rural livelihoods. This may involve strengthening farmer/community management of existing agricultural biodiversity on-farm and increasing access to a range of agricultural biodiversity and to related skills and technologies in order to use agricultural biodiversity more effectively. In *industrial-type agriculture*, the emphasis may be more on modifying the genetic basis of plant breeding through base broadening and participatory approaches, and strengthening the ex-situ conservation of agricultural biodiversity. These are actions that require national level action. Even in industrial-type agriculture, some vulnerable groups may be dependent on on-farm agricultural biodiversity, and in such areas it will be important to protect this resource base at the local level. In both areas, there are good reasons to promote integrated pest management which relies on the biodiversity of natural enemies of pests and good management of soil biota.

At the **national level**, it is important to provide an enabling environment that will support local level actions aimed at strengthening the livelihoods of the rural poor. But there is also another dimension to consider at this level. The well-being of the urban-poor and the non-food producing rural poor, is improved by a plentiful and cheap food supply. Thus a total poverty elimination strategy will require appropriate institutional arrangements (including those for conservation and access of genetic resources, and plant breeding) at the national level to support sustainable crop production in both traditional and industrial-type agricultural systems.

Agricultural biodiversity underpins food security at the **global level** too. Thus, in addition to supporting local and national level needs, global level policies and programmes should also ensure adequate conservation of agricultural biodiversity and sharing of its benefits in the aggregate.

The next Section will explore these entry points. Note that there is already an international mandate for nearly all these actions – local, national and global – in the decisions on agricultural biodiversity agreed by the Conference of the Parties (COP) to the Convention on Biological Diversity, and the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (see Table 4.1).

Table 4.1: Key international agreements on conservation, sustainable use and benefit-sharing of agricultural biodiversity

Agreement	Status	Relevant Issues
Convention on Biological Diversity	Legally-binding on the 174 states that have ratified it. Entered into force Dec. 1993	Conservation, sustainable use and sharing of benefits
CBD/CoP decision III/11	Programme of work agreed Nov. 1996and developed further May, 2000 at CoP V	Agricultural biodiversity
Cartagena Protocol on Biosafety	Expected to enter into force in 2001	International Transfer of Living Modified Organisms (LMOs)
International Undertaking on Plant Genetic Resources	Currently under revision through negotiations in FAO Commission on Genetic Resources for Food and Agriculture. Expected to be a legally-binding instrument, possibly as protocol to CBD	Multilateral system of facilitated access to some PGRFA, with mechanism for sharing of benefits derived from the use of PGRFA; Farmers Rights (including right to re-use saved seed)
Global Plan of Action for the conservation and sustainable use of PGRFA	Agreed by 150 states at FAO International Technical Conference, Leipzig; Endorsed by CBD/CoP and World Food Summit	In-situ management, ex-situ conservation and use of PGRFA with capacity building and institutional strengthening
WTO agreement on Trade Related Intellectual Property Rights	Legally-binding on WTO member states, with dispute panel	Includes IPRs over genetic resources, allows for exclusion of plants and animals from patenting, but requires *sui generis* system for plant varieties
Review of TRIPS 27.3(b)	Pending	As above
UPOV Convention	1991 agreement now in force	A *sui generis* system for intellectual property protection of plant varieties

5: Using agricultural biodiversity to reduce poverty: policy options and entry points

This section outlines the ways in which agricultural biodiversity can be used for poverty reduction, development and food security across the spectrum of stakeholders. In addition to these practical actions, there is also a need to raise the profile of the conservation and sustainable use of agricultural biodiversity

5.2 Local level

5.2.1 Access to and better management of natural resources

Agricultural biodiversity conservation

Existing agricultural biodiversity has to be conserved in order to ensure access to it now and in the future. Because it is a product of human management as well as natural genetic resources, this necessarily involves human intervention. Therefore, in-situ conservation approaches are primarily in the form of on-farm conservation rather than protected areas. It is also now recognised that the use and conservation of agricultural biodiversity is determined by the context of the whole agro-ecosystem, including ecological, economic, social, and political factors, and so in-situ conservation must take an agro-ecosystem approach. However, there is still an important role for ex-situ conservation.

In many agricultural systems, farmers actively conserve agricultural biodiversity on-farm as an important element in contributing to sustainable livelihoods. In other systems, components of agricultural biodiversity may be important to particular groups or for particular purposes. In both these situations, on-farm – or near-farm – agricultural biodiversity conservation activities may be justified, but are likely to be sustainable only when linked to productive processes.

In other circumstances, conservation of agricultural biodiversity may be important from a national or global perspective, but is not part of the agenda of local communities. Here, on-farm conservation should be promoted only where the resources are of extreme importance. Compensatory activities will be required to ensure that the concerned communities are not worse off from such approaches, and that they share equitably in the benefits realised at higher levels. This is important both for reasons of equity and for the sustainability of the activities concerned. This kind of conservation at the local level for global benefit cannot be classified as a 'development' activity, so funding for it should not be through official assistance, but from non-aid sources, such as the Global Environmental Facility.

Measures to conserve agricultural biodiversity in-situ include:

- incentives and other measures to promote the cultivation of local varieties and minor crops (covering marketing, research support, improvements to the physical quality of planting material);
- promoting the use of alternatives to agro-chemicals which damage 'weed' food plants, or upset pest-predator dynamics, or destroy insects that are important sources of protein for households, e.g. termites;
- promoting techniques and technologies to enable communities to protect local agricultural biodiversity, such as community seed banks.

Table 5.1: Agricultural biodiversity contributions to sustainable livelihoods

Objective	Type of entry point	Examples from existing projects
Access to and better management of natural resources	Agricultural biodiversity conservation	Seeds of Survival, Ethiopia MASIPAG, Philippines
	Access to germplasm	**Maragwa seed fair, Kenya** SALRED, Zimbabwe
	Quality seed production	KOSEPAN, Nepal
	Integrated crop management	**NOPEST, INTERFISH, Bangladesh**
	Natural resources research	ICRAF Alternatives to Slash and Burn project; DFID ERP 'ABC'project
More supportive social environment	Recognising indigenous knowledge	Agrobiodiversity & IK Research project, Malawi
	Increasing farmers' 'voice'	Chivi Food Security Project, Zimbabwe
Access to financial resources	Income-generating projects	KOSEVEG, Nepal
	Ag. biodiversity tourism	**IPBN, Peru**
Education, information, training, technologies, nutrition	Agricultural research	**CIALs, Colombia, Farmer Fields Schools, Indonesia, KHRIBCHO, India**
	Agricultural extension and education	**Farmer Field Schools, Indonesia**
Access to facilitating infrastructure	Access to agricultural markets and services	Tharaka-Nithi farmers project, Kenya
	Developing local markets for biodiversity-friendly ag. products	
Policy and institutional environment	National planning system	Country reports to the 4th international technical conference on PGRFA 1996
	National legal and policy coordination	
	Ag. biodiversity assessment and monitoring	Biodiversity support programme, PNG
	NARS	
	Access to genetic resources	National PGR Centre, Zimbabwe
	Seed regulatory framework	National revisions in India, Turkey
	National ag. extension policies	**AGRITEX, Zimbabwe**
	Emergency relief and rehabilitation	Seeds of Hope II, Horn of Africa
	Participation in global negotiations	
Global policy and institutions	International agricultural research system	CG SWIs on genetic resources; on participatory research
	Aid, development and environment programmes	Global Environmental Facility; DFID World Aware
	International agreements and fora	CBD, International Undertaking, Biosafety Protocol, TRIPs
Policy consistency		

Note: **Bold** = projects described in Section 5.

Access to germplasm

The conservation of agricultural biodiversity makes little contribution to sustainable livelihoods unless the conserved resources are accessible. Relatively effective channels exist for ensuring access by formal sector plant breeders and other agricultural scientists, and the institutions employing them; much less attention has been paid to ensuring access by farmers. Options for improving this access include**:**

a) Farmer-to-farmer seed exchange mechanisms

Including:

- traditional one-to-one exchange between neighbours, relatives, etc;
- seed fairs, which can be used to increase farmers' awareness of modern varieties as well as farmers' varieties (see Box 5.1);
- importation and testing of farmers' varieties from other areas to see if they meet local farmers' needs;
- community seed banks to allow seed or planting material of local varieties and minor crops to be kept safely from one season to another and to be made more widely available to local farmers.

b) Improved linkages with the formal seed sector

- Promoting the concept of a national gene bank as a clearing house for germplasm, and improving the information available to farmers on the genetic material available in it;
- Incorporating farmer participation into formal sector plant breeding (see Section 5.2.4).

Box 5.1: Farmer-to farmer seed exchange mechanisms

Seed fairs

Seed fairs are increasingly popular modes of promoting diversity. In Maragwa, Kenya, fairs have been held annually since 1996, having been initiated in an NGO project development area. In 1998, displays were mounted by 29 women and 47 men, as well as some community groups. The displays are evaluated by a panel of judges and the most diverse are awarded prizes. The total number of crop varieties displayed increased from 134 in 1997 to 149 in 1998.

The reasons given for farmer participation in the fair included:

- obtaining rare crop varieties
- identifying seed sources
- a good forum for exchange of ideas on farming and exchange of seeds
- exposure to national agricultural research work
- the spirit of competition boosts farmers' morale, encourages crop diversification and, indirectly, enhances food security
- a platform for interaction between farmers, students, researchers, extension staff and other development agents.

Farmers also noted that, to enable community to sustain the seed show, several developments are necessary:

- selecting a seed show committee to raise and manage funds for organising the event
- introducing certificates of participation
- initiating an inter-village seed show so that competition is between villages rather than individual farmers
- providing financial back-up to the Location Development Committee to enable it to organise and run at least two consecutive seed shows independently
- introducing other categories, eg food processing, crop husbandry, livestock care and others to respond to the wider issues facing farmers

Source: IT-Kenya internal report

Quality seed production

The genetic potential in agricultural biodiversity is useless unless it is delivered to farmers effectively. In the case of crop genetic resources, this is through the medium of quality seed, which has both genetic and physiological components.

For farmers in industrial-type agricultural systems, seed from national seed companies can be problematic in terms of poor physical quality, damage in transit, non-availability of preferred varieties, late delivery, etc. Action may be necessary to improve the quality of seed produced, ensure quality control during delivery and timeliness, and improve seed demand estimates.

Farmers in traditional-type agricultural systems who are more reliant on seed of local farmers' varieties, may also face problems of short supply and poor physical quality, especially if local environmental conditions support seed pests and diseases in field or in store. One solution is to provide technical back-stopping to local level seed multiplication, eg. promoting farm or village level seed production enterprises focusing on producing quality seed. This has the added advantage of having the potential to become a local level income-generating business under certain circumstances. One constraint can be the obligation to comply with cumbersome and expensive national seed quality standards which are usually originally developed for large-scale mechanised seed production and processing operations. These are primarily aimed at farmers in industrial-type agriculture who may require standards, such as uniform seed size for mechanical planting, that are irrelevant to farmers in traditional-type agricultural systems. A review of seed regulations at national level (see Section 5.3) may be appropriate if this is the case.

Integrated crop management

This has come to mean the use of biological relationships within the farm agro-ecosystem to reduce reliance on external inputs and improve productivity, and is clearly an approach of direct relevance to using agricultural biodiversity for sustainable livelihoods. Farmers in traditional systems already rely heavily on ICM approaches, because of economic and practical barriers to accessing agro-chemicals, but in industrial-type agricultural systems it is only recently that farmers and scientists have come to realise the value of these approaches. Integrated pest management (IPM) is perhaps the best-known ICM approach, using better management of pest-predator relationships to reduce reliance on chemical pesticides and increase productivity. In addition, this whole system approach can also be used to improve crop nutrient management, by managing below ground agricultural biodiversity, including plant root architecture, rhizobia and soil biota, etc.

Box 5.2: Integrated Pest Management: IPM in rice-fish cultivation in Bangladesh

Since 1992 CARE, an international NGO, has been working with farmers in Bangladesh to improve rice-fish cultivation. Integrated Pest Management has been promoted through the NOPEST and INTERFISH projects supported by DFID, using participatory action learning approaches pioneered by FAO in Indonesia and the Philippines. CARE adapted the Farmer Field School approach already being promoted by the Bangladesh Department of Agriculture and Extension. In each community involved in the project, farmers come together for weekly half-day ‘Farmer Field Schools’ where they learn and experiment with IPM techniques based on agro-ecological principles. Through experimentation on their own fields, they observe, for example, pest-predator population dynamics, and the capacity of rice plants to recover from defoliation. Through improved crop and agro-ecosystem management, they are able to achieve rice yields that are not only 7-8% higher, but also very much more stable from season to season, while dramatically reducing pesticide inputs. In addition to the wider environmental and health benefits, the latter also permits fish production which supplies more than 70% of the rural population’s protein. The programme is being extended with DFID funding and plans to reach about 90,000 farmers, including about 20,000 women by 2000.

Source: Ingram and Kamp, 1996

5.2.2 More supportive social environment

For agricultural biodiversity, there are two interrelated objectives:

- to recognise and facilitate the role of farmers in maintaining and managing agricultural biodiversity;
- to increase the voice and power of weaker stakeholders, in order to achieve a more equitable sharing of the benefits of using agricultural biodiversity.

In meeting either of these objectives, the interest and capacity of individuals and communities to manage agricultural biodiversity varies significantly, so strategies and activities must be tailored accordingly.

Recognising indigenous human knowledge

Farmers' existing indigenous knowledge and the cultural environment in which they manage biological biodiversity need to be more appropriately recognised by formal sector scientists and development workers. In addition support and capacity building to self-help groups such as seed groups and community seed banks should be provided. This could include technical support and business and group advice, which have the additional advantage of implicitly validating what such groups are doing. As part of this recognition, it may be necessary to find new ways of sharing the benefits of farmers' agricultural biodiversity conservation more fairly with them.

Increasing farmers' voices

This involves empowering farmers to place effective demands on national genetic resources systems, and can include providing access to information, supporting legal literacy and access to the justice system – including support to advocacy groups and CSOs – and supporting rights to equality of opportunity and participation in public life.

It may also include strengthening local community organisations to allow farmers and communities to articulate their needs for, eg, a wider choice of high quality planting material; more appropriate technologies; training; or research support, as well as to exercise a more effective 'demand pull' on national agricultural research and other support systems. This would encourage a truly 'bottom-up' development process. The Farmer Field School approach to participatory research is a useful tool for this purpose, as it gives farmers a technical base for empowerment.

5.2.3 Access to financial resources

Access to financial resources is a constraint to livelihood decisions for many farmers, particularly those in traditional-type agricultural systems. There are a number of ways in which agricultural biodiversity can be used to generate financial resources:

- income-generating projects:
- local seed production;
- community seed banks;
- tourism: Northern consumers and more affluent consumers from the South are increasingly interested in agricultural biodiversity, as well as wildlife and landscapes (see Box 5.3).

Box 5.3: Agricultural biodiversity tourism in Peru

In Cusco, during guided tours to the community, tourists are shown the morphological and agronomic variety of Andean plants and tubers in demonstration plots, a potato museum and restaurants with menus based on traditional Andean produce, as well as displays of Andean camellids. This initiative provides incentive for on-farm conservation of Andean crops, supports a school education programme about Andean crops and culture, and involves young people in agro-ecotourism as a means of reducing out-migration.

Source: FAO, 1999

5.2.4 Education, information, training, technologies, nutrition

Agricultural research

Farmer participation in agricultural research ensures that research products are more suited to enabling farmers to generate sustainable livelihoods from using agricultural biodiversity than more conventional research methods. Farmer Field Schools are a useful forum for grass-roots participatory research, which provide community-level experimental plots and technology development. Similarly the community Committees for Agricultural Investigation (CIALs) used in Colombia have also been successful in institutionalising farmer participation in adaptive technology testing. These are described in Box 5.4. It is important to remember that the applicability of these opportunities will depend on the existing capacities of different farmers and farming communities.

As we saw in Section 2.2, formal sector plant breeding serves industrial-type agriculture quite well, although there are arguments in favour of broadening the base of breeders' collections. Greater emphasis is needed on improving relevance to farmers in traditional-type agricultural systems.

Present practices for the development and release of new varieties require a lengthy testing phase. Making germplasm from the formal sector available to farmers at an earlier stage in the process, for example through participatory plant breeding, enables farmers to participate by making choices between material, and adapting it to local conditions through further farmer selection. Providing farmers with a greater choice of genetic material, including the provision of varieties which can be used in mixtures, is also relevant. Depending upon local social structures, the participation of particular farmers in breeding programmes will not necessarily guarantee that all farmers in the community benefit, or even that the needs of other farmers will be identified. The poorest and most vulnerable groups can still be marginalised by 'participatory' approaches.

One of the problems with using agricultural biodiversity in daily life always highlighted by farmers is the difficulty of getting 'non-standard' crops and varieties processed, and finding a market for any surplus production. In Southern Africa, for example, local hammer mills are designed to process modern variety soft dent-type maize, but cannot cope with local flinty maize or small grains such as millet. Consequently these have to be processed on-farm by hand which is time-consuming, laborious and a major disincentive to growing them in large quantities. Thus, there is a need to support post-harvest activities, such as the development of small-scale processing equipment for local crops and varieties; the development of alternative products from local crops and varieties and their by-products, and to boost market opportunities.

Box 5.4: Two approaches to participatory research

Farmer Field Schools These are a form of community based, non-formal adult education which have been promoted by FAO through its inter-country programmes for integrated pest management (IPM) in Asia. The FFS comprise season-long education and training activities where a group of around 25 farmers meet regularly (usually for one morning, each week) in the field to learn about the rice ecosystem through self-discovery and experimentation, based on a firm understanding of ecological principles. This approach has empowered farmers to become better managers of their crops, and thereby to improve production whilst substantially reducing pesticide inputs.

To date over one million Indonesian farmers have graduated from FFSs, over 400,000 in Vietnam, and over 170,000 in the Philippines. The Programme has been extended to several other Asian countries, and now, through the Global IPM Facility, to many countries in Africa and elsewhere. It has also been extended to other crops such as vegetables, maize and cotton.

Scale up is achieved through the ‘cascade effect’ of training of trainers. The impact at community level is extended and sustained through ‘Community IPM Clubs’ formed spontaneously by the FFS graduates themselves after the formal FFSs have ended. In many countries support of local government and extension services, also guarantees the sustainability of the approach. The programme has also had major policy impacts at national level, for example, in terms of reduced subsidies for and increased taxes on pesticides. FAO’s role has been to initiate FFS programmes; link them with national and local government; and facilitate the learning of lessons, both for improved projects on the ground, and for policy change.

Now the approach is also being used to promote, for example, integrated plant nutrient systems and other aspects of crop management which can facilitate sustainable intensification. Indeed the success in IPM has resulted largely through a better overall crop management. In Bangladesh, CARE has used this approach in their NOPEST and INTERFISH projects to promote rice-fish culture with vegetable planting on the dikes. In the Philippines NGOs such as CONSERVE (in Mindanao) and SEARICE (in Bohol, Visayas) have used FFS to improve the management and use of crop genetic resources, through farmer selection of off-types, participatory varietal selection of introduced varieties, and also true participatory plant breeding selection from segregating populations. Now FAO is actively exploring the wider application of this approach.

Source: Cooper, pers. comm 1999

Committees for Agricultural Investigation (CIALs)

New crops and new varieties are given high priority in the topics selected for local experimentation by farmers in local research committees (CIAL’s or *Comites de Investicaion Agropecuria Locales*). Such CIALs have been set up in Colombia to mobilise local leadership among farmers to take responsibility for experimenting with technologies new to their community. The CIAL project aims to create ‘demand-pull’ by clients of public sector research organisations, and thereby to increase the number and rate of flow of technologies available to resource-poor farmers and contribute to improved livelihoods. On 30 CIALs which have conducted varietal trials, a total of 47 landraces, 50 farmer-introduced landraces obtained from outside the area, and 259 exotic materials have been evaluated. Farmers benefit from the faster introduction of improved varieties. On the other hand, farmers’ experimentation with landraces continues to be a feature of varietal selecting as several CIALs are concerned to ‘rescue’ and multiply seeds of their local germplasm and to maintain a diversified portfolio of genetic materials in their fields. Some CIALs have evolved into small-scale seed production enterprises delivering seed of their own selections to other farmers in the area. Seed is sold, with state approval, under the category of ‘farmer-improved seed’. More than 10,000 farmers purchased seed originating from six CIALs. Farmers have benefited from improved quality seed, and the seed enterprises have also generated local employment.

Source: Ashby et al., 1995 and 1996

Agricultural extension and education

Many of the opportunities for using agricultural biodiversity for sustainable livelihoods require farmers to deepen and broaden their understanding and application of, for example, ecological principles. These include pest-predator population dynamics, nutrient cycling, and genetic principles of crop improvement. This education may then provide the basis for training in specific skills such as participatory plant breeding. In many traditional farming systems, farmers know much about this already, so the need is to find ways of combining this knowledge with scientific knowledge. In industrial farming systems, farmers may need to be taught afresh. Farmer Field Schools have been very successfully used for field-based informal adult education to improve farmers' methods in IPM, and this approach is now being extended to other aspects of integrated crop management.

5.2.5 Access to facilitating infrastructure

As well as the need to ensure access to agricultural markets and services, there is the need to develop local markets for biodiversity-friendly agricultural products[20]. It can be difficult for farmers growing local varieties to find a market for their products, and markets may also be subject to greater uncertainty concerning prices, etc. With the increasing commercialisation of most local economies, there are fewer opportunities to generate income or to barter traditional items, such as straw baskets, etc, made from the by-products of indigenous crops and varieties: it is easier and sometimes cheaper for households to buy manufactured items from the local market. Both private sector and state crop purchasing facilities often take crops grown from modern varieties in preference to local varieties, because the former better meet the needs of the industrial processors who ultimately buy the crop.

Developing alternative products from local crops and varieties and their by-products is one way of boosting market opportunities for agricultural biodiversity. Others include:

- adding value to the product so producers gain more revenue;
- validating such products locally and raising awareness of their nutritional, environmental, and economic benefits;
- including products made from local crops and varieties and their by-products in local income-generating projects and programmes;
- enhancing community capacity in marketing skills, price negotiation, etc.

5.3 National level

Policy and institutional support at the national level is required to enable the implementation and replication of local level initiatives. This may involve sector programmes, institutional support, and policy support units. Actions to permit individual countries to participate actively in the various international fora in which important decisions about the conservation, use and access to agricultural biodiversity are made are an important part of this support.

5.3.1 National planning system

Agricultural biodiversity issues need to be mainstreamed into the policies and activities of all organisations, rather than, for example, having an isolated national plant genetic resources programme housed in a new national plant genetic resources centre with little contact with other stakeholders. Amongst other actions, mainstreaming requires that agricultural biodiversity is included in national sustainable development strategies (NSDSs), national

20 Developing international markets is also important, but this is dealt with in Section 5.4.2 below.

biodiversity action plans, and agricultural development plans.

The necessity of achieving cooperation by all actors, relevant departments and organisations with a direct or indirect stake in agricultural biodiversity is now recognised and forms a key component of the Global Plan for the Conservation and Sustainable Use of PGRFA.

This requires that the development planning process is carefully co-ordinated amongst institutions and involves all stakeholders, including farmer/community representatives. This may require training for national policy makers in technical and economic issues relating to agricultural biodiversity in order to improve their capacity to deal with these issues.

5.3.2 National legal and policy coordination

Policies and legislation designed and implemented at the national level for other purposes can directly affect the sustainable use of agricultural biodiversity. The most obvious example is the incentive to convert to industrial-type agricultural systems and reduce the use of agricultural biodiversity by subsidy schemes for purchased agricultural inputs, but others, including ensuring agricultural marketing policies support agricultural biodiversity, are also important.

Therefore, the impact of the national legal and policy framework on agricultural biodiversity and poverty reduction must be kept under review. Such reviews should be a participative process involving all stakeholders. The reviews should include national legislation and other measures implementing the WTO/TRIPs agreement, to determine its impact on the conservation and sustainable use of agricultural biodiversity and whether the benefits from the use of this resource are being equitably shared.

5.3.3 Agricultural biodiversity assessment and monitoring

Even where specific agricultural biodiversity conservation measures may not appear to be justified at the outset, surveys and assessments of agricultural biodiversity and its importance to local communities should be made. These can bring to light specific opportunities for using agricultural biodiversity to reduce poverty. Agreement on standardised agricultural biodiversity indicators has still not been reached internationally, but should be a priority. There are various manuals offering guidance on how to conduct biodiversity assessments[21], which should always be carried out with the full involvement of local communities.

5.3.4 National agricultural research system

NARSs need to be reoriented to address the needs of farmers in traditional-type agricultural systems as well as those in industrial-type agricultural systems by, for example, including research on crops that are important in traditional systems and on low external input agricultural systems. In addition, research techniques need to be reoriented so that results are accessible to farmers in traditional-type agricultural systems; an example of this is the use of participatory plant breeding.

5.3.5 Access to genetic resources

Ensuring the availability of agricultural biodiversity to both farmers and breeders is important. This requires policies that achieve a complementary mix of in-situ and ex-situ conservation and secure access to plant genetic resources from other countries through appropriate

21 For example, UNEP, 1993; Prescott-Allen, 1998 (draft).

agreements.

5.3.6 Seed regulatory framework

Developing flexible policies towards farmer-saved seed, seed exchange, seed certification and variety release is important. For further information, see Tripp and Louwaars, 1997.

5.3.7 National agricultural extension policies

The focus and methods of the national agricultural extension system should be re-oriented towards supporting the use of agricultural biodiversity by farmers in both traditional and industrial-type agricultural systems. NGOs and CBOs may need to be involved given that government extension services are in decline in many countries.

5.3.8 Emergency relief and rehabilitation

Conventionally, any seed is supplied that is broadly adapted to the affected agro-ecological zone. This is not adequate and great care must be taken to tailor the crop and variety distributed in relief packages to the precise conditions in local farming systems. This is important not only in terms of the direct use that can be made of the relief seed, but also in terms of the knock-on effects that it may have at household or local economy level (see Box 5.5).

Box 5.5: Inappropriate seed relief in Mozambique

At one point during the civil war in Mozambique, farmers in one remote rural area were supplied with hybrid maize seed by an agency. This provided them with a crop in the first year, but seed needed to be saved from the crop for the following season, as there was no regular, formal sector seed distribution in the area. Being of hybrid varieties, the seed they saved yielded extremely poorly the following year, so they were again unable to sustain themselves without outside support. The whole exercise was even more disastrous because farmers did in fact have some small supplies of composite maize seed hidden in reserve – it is often the case in emergencies that farmers manage to preserve some seed. However, on receiving the hybrid maize seed, they were keen to plant this, and used their own stocks of seed as food.

The issue of grain purchase for food distribution is also pertinent. If relief agencies re-orientate their emphasis on distribution of single to a range of commodities (eg from maize to minor but nutritious crops, such as sorghums, and millets in Southern Africa) this may stimulate farmers to produce for the relief market to diversify production.

Emergency seed distribution activities should be based on a pre-planning survey, much of which can be conducted in advance as a disaster-preparedness activity. Detailed guidance on how to plan and implement seed provision during and after emergencies can be found in ODI (1996).

5.3.9 Participation in global negotiations

Because of the high degree of interdependence between countries concerning agricultural biodiversity, it is essential that all countries can participate effectively in the wide range of global negotiations which increasingly determine agricultural biodiversity conservation, use and benefit-sharing. This would have a critical influence on individual countries' freedom of choice concerning opportunities for using agricultural biodiversity for poverty reduction.

This may require strengthening the capacity of national negotiators in technical and economic issues relating to agricultural biodiversity, and of staff in all the different national ministries and agencies with a direct or indirect impact on agricultural biodiversity, including agriculture, trade, environment, etc. Although these activities relate to international fora, they all require funding at individual country level. For many donors, existing funding mechanisms may not cover this.

In many fora, it may be appropriate for individual countries to come together in blocs with those with similar concerns and interests. There are also increasing calls for a mechanism to enable South-South exchange of grassroots agricultural biodiversity conservation and management experience (FAO, 1999).

5.4 Global level

Opportunities at the global level for supporting the use of agricultural biodiversity for poverty reduction fall into two categories: firstly, those that promote the activities described above at national and local levels; and, secondly, some actions that can most effectively be carried out only at supra-national level. These include long-term conservation; genetic enhancement of major crop gene pools; international frameworks for conservation, sustainable use and benefit sharing. These actions can be implemented through three channels, as follows:

5.4.1 The international agricultural research system

Using agricultural biodiversity for sustainable livelihoods requires a continuing commitment to research, in order to improve our understanding of various as yet unclear ecological and economic relationships. The key research gaps in ecology, economics and agriculture include:.

Environment research on:
- the contribution agricultural biodiversity can make to sustainable agriculture;
- defining agreed indicators for agricultural biodiversity assessments;
- factors determining the rate of extinction in agricultural biodiversity;
- co-dependency between different components of agricultural biodiversity.

Socio-economic research on the valuation of ecosystem functions and services.

Plant sciences research on the role of roots in crop growth and in agro-ecosystem functioning.

There is also a need for more case studies documenting farmers' agricultural biodiversity management practices at field level: there is surprisingly little knowledge about the technical and socio-economic details of this (FAO, 1999).

The International Agricultural Research Centres of the CGIAR, as the backbone of the international agricultural research system, should focus their work related to agricultural biodiversity on:
- supporting the international network of ex-situ gene banks;
- facilitating genetic enhancement or base broadening of major crop gene pools available to national public and private plant breeders;
- supporting a decentralised approach to plant breeding;

- monitoring the progress and outcomes of gene transfer carefully (note that at the October 1998 Centres Week, the CG system decided that none of its plant breeders will use 'any genetic system designed to prevent germination'[22]);
- contributing to the capacity building of national programmes, with wide stakeholder involvement, in order that national programmes as well as farmers and their communities can exert a 'demand pull' on the international agricultural research system;
- developing methodologies in support of local agricultural biodiversity conservation and sustainable use.

5.4.2 Aid, development and environment programmes

The activities indicated in previous sections can be promoted through bilateral aid programmes, and through multilateral organisations (such as FAO and other UN specialised agencies, UNDP, the World Bank, IFAD and the regional development banks). In order to address purely global concerns, these mechanisms are supplemented by, for example, the Global Environment Facility.

Agricultural biodiversity should be included in development education programmes. And awareness-raising amongst Northern consumers is also important in order to publicise the ecological and social 'foot prints' of their food consumption patterns and to promote the consumption of food from biodiversity-friendly agricultural production systems. In this regard, it may be possible to build on the current stimulation of markets for organic produce, and the promotion of ethically traded goods (see Box 5.6).

Box 5.6: Promoting 'biodiversity-friendly' products

In El Salvador, a GEF-assisted project is supporting ecologically sustainable and bird friendly 'shade coffee' production by creating a certification system and marketing this kind of biodiversity-friendly production system abroad, especially in the US. This has resulted in the ability to charge a 5% price premium. Distribution systems and educating financial institutions about the financial as well as the environmental value of such coffee were also necessary.

Source: FAO, 1999

5.4.3 International agreements and decision-making fora

The framework of international law and regulations should:

- facilitate access to genetic resources and related information and technologies to prevent monopolistic conditions. These are influenced by IPR law and exemptions, specific regulations on access, and potentially by anti-trust measures;
- provide for biosafety, in terms both of protecting the environment and of avoiding damage to livelihoods through vulnerability to agricultural systems;
- provide for the various aspects of Farmers Rights required for farmers and communities to conserve, develop and share in the benefits arising from the use of agricultural biodiversity.

Concerning international agreements under development or review the most critical are:

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22 New Scientist, 7 November 1998:5.

- The International Undertaking on Plant Genetic Resources is currently under revision and needs to include agreements to facilitate access to plant genetic resources, with minimal restrictions, and for the full implementation of Farmers' Rights including the right to re-sow saved seed. Funding issues, possibly including funding of the Global Plan of Action, are also under discussion, as are several critical issues of Farmers Rights;
- Various matters being discussed under the Convention on Biological Diversity, including matters relating to access and benefit sharing, traditional knowledge, and implementation of the Cartagena Protocol on biosafety, as well as implementation of thematic work programmes particularly the programme of work on agricultural biodiversity.
- The upcoming review of the agreement on Trade Related Intellectual Property Rights should maintain the option to exclude plants and animals from patenting (while providing a *sui generis* system for plant varieties). International obligations such as the WTO/TRIPs agreement should be implemented in a way consistent with national interests[23].

5.5 Conclusions

Taken together, the opportunities for action at local, national and global levels to support the wider use of agricultural biodiversity to reduce poverty, promote development and improve food security, imply that a new approach to agricultural research and development is needed. The original approach has provided many successes, but these have been largely concentrated in industrial-type agriculture - often irrigated or subjected to a high level of inputs- and for generic technologies with widespread applications, for example, the modern varieties of wheat and rice developed through breeding for wide adaptation. The new approach is more complex, based on strategies aimed at farming systems rather than particular crops, and less reliance on external inputs. It requires greater appreciation of the multiple goods and services provided by biological diversity in agricultural ecosystems. This new approach also requires greater involvement of farmers, local communities, and indeed the whole array of civil society organisations at local and national level.

23 For more on this, see Leskien & Flitner, 1997.

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Acronyms

Bt	Bacillus thuringiensis
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CIAL	Committee for Agricultural Investigation (Columbia)
COP	Conference of the Parties (to the Convention on Biological Diversity)
CSO	Civil Society Organisation
CSP	DFID Country Strategy Paper
DFID	UK Department for International Development
EPD	DFID Environment Policy Department
EU	European Union
FAO	UN Food and Agriculture Organisation
FFS	Farmer Field School
GDP	Gross Domestic Product
GEAF	DFID Global Environmental Assistance Facility
GEF	Global Environmental Facility of the World Bank
GIFTS	Germplasm, Information, Funds, Technologies, and farming/marketing Systems
GIS	Geographical Information System
GMO	Genetically modified organism
ICM	Integrated crop management
IFAD	UN International Fund for Agricultural Development
IPM	Integrated pest management
IPR	Intellectual Property Rights
ITDG	Intermediate Technology Development Group
ITK	Indigenous technical knowledge
IUCN	International Union for the Conservation of Nature
MV	Modern variety
NARS	National agricultural research system
NGO	Non-governmental organisation
NR	Natural Resources
NSDS	National Sustainable Development Strategy
ODI	Overseas Development Institute
PA	Protected area
PGRFA	Plant genetic resources for food and agriculture
RNRRS	DFID Renewable Natural Resources Research Strategy
TRIPs	Trade related aspects of intellectual property rights
UPOV	Union for the Protection of New Varieties of Plants
WTO	World Trade Organisation

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