Agriculture, biodiversity and livelihoods: issues and entry points

Final Report

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FOREWORD

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Any errors or omissions remain the responsibility of the author, and the views expressed in this report are those of the author and do not necessarily reflect those of other individuals or institutions.

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Acronyms

Bt	Bacillus thuringiensis
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CIAL	Community 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

EXECUTIVE SUMMARY

What is agricultural biodiversity?

Agricultural biodiversity encompasses 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 for, and in support of, food production and food security. Many people say that local knowledge and culture are also integral parts of agricultural biodiversity, because it is the human activity of agriculture which conserves this biodiversity through sustainable use.

It is important to note that, although millions of farmers around the world use, manage and develop agricultural biodiversity on a practical, daily basis, the governance of its conservation, sustainable use and benefit-sharing is determined at an international level by a number of agreements – particularly the Convention on Biological Diversity, the International Undertaking on Plant Genetic Resources, the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture and the WTO/TRIPs agreement.

Agricultural biodiversity is essential to the world for three main 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;
- ecological services provided by agro-ecosystems, such as landscape protection, soil protection and health, water cycle and quality, air quality.

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. This creates a very great 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 of agricultural biodiversity, its conservation in production systems is inherently linked to sustainable use – preservation through protected areas is of less relevance;
- nonetheless in industrial-type agricultural systems, much biodiversity is now held ex-situ in gene banks or breeders' materials rather than on-farm.

Agricultural biodiversity is highly dynamic, being determined by a matrix of 'human' factors and feedbacks, in addition to underlying natural conditions. There is increasing realisation of the importance of agricultural biodiversity at the ecosystems level, as well as at the species and genetic level, and the agro-ecosystems approach to agricultural biodiversity conservation is widely promoted. There is no such thing as an *a priori* 'optimum' level and mixture of agricultural biodiversity in an agro-ecosystem; the desirable configuration is determined by prevailing local natural and – equally importantly – socio-economic circumstances.

Agricultural biodiversity, poverty and development

It is sometimes said that development and agricultural biodiversity are in opposition, and that development involves the 'conversion' of diverse areas to 'more productive' areas. This is a simplification.

Farmers in both more 'traditional' and more 'industrial' agricultural systems rely on using agricultural biodiversity as an integral part of their production strategies. In more industrial systems, crop diversity may be lower on-farm because – IF the necessary supporting infrastructure is in place – it can be stored (in gene banks) and manipulated (by plant breeders) off-farm. Non-crop agricultural biodiversity may remain significant on-farm and very important for biological support and ecological buffering. In more traditional systems, farmers actively manage agricultural biodiversity on-farm in order to improve productivity and maintain sustainability; and adapt to changing needs and circumstances and the need is to enable them to continue to do this. Given that global food security depends significantly on production in more industrial agriculture, it is relevant to note the important contribution of agricultural biodiversity to global food production as well as to sustainable livelihoods in more traditional agricultural systems. In addition to these production effects, agricultural biodiversity also contributes indirectly to sustainable livelihoods through the provision of important ecosystem functions and services. And it contributes to the livelihoods of a wide range of other stakeholders.

Multinationals, Northern and Southern consumers, scientists and the international gene bank system are important stakeholders in agricultural biodiversity, and their voice and market power can sometimes overshadow those of farmers. A global regulatory framework is needed to ensure the value of agricultural biodiversity is appropriately captured at each level in the stakeholder hierarchy.

Opportunities for using agricultural biodiversity for sustainable livelihoods

For the reasons outlined above, it is inappropriate to promote large-scale abandonment of biodiverse agriculture and to marginalise it in intensive production systems. 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. This will involve breaking down the economic incentives, institutional and policy barriers that currently exist against using agricultural biodiversity sustainably, by correcting the pull in policy, research, and implementation towards the globalisation of the industrial-type agriculture model.

We can strengthen and build upon farmers' own efforts by action at local, national and global levels as outlined below. There is already an international mandate for nearly all these actions in the form of the Decisions on agricultural biodiversity agreed by the Conference of the Parties 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 (these are summarised in Appendices.)

a) Local level

- Support on-farm conservation of agricultural biodiversity using incentives appropriate to the context.
- Support farmer-to-farmer seed exchange, including seed fairs and community seed banks, where it is effective.
- Enhance local level seed production by providing technical back-stopping and business advice.

- Promote integrated crop management.
- Commit to continuing natural resources research on agricultural biodiversity.
- Strengthen local community organisations to increase farmers' voice on agricultural biodiversity issues.
- Promote income-generating projects that use agricultural biodiversity.
- Promote participatory agricultural research and plant breeding.
- Strengthen local level capacity for agricultural biodiversity management and use, including tools such as Farmer Field Schools.
- Invest in developing local markets for biodiversity-friendly agricultural products.

b) *National level*

- Support the mainstreaming and better coordination of national genetic resources policies and programmes, including wider stakeholder involvement in planning and implementation, and capacity building for national policy makers.
- Fund reviews of the national legal and policy framework and its impact on agricultural biodiversity. If indicated, fund work to revise seed regulatory frameworks to end legal and institutional restrictions on farmers' own activities in varietal improvement and seed exchange.
- Invest in national biodiversity assessments as a planning tool (i.e. not simply for information generation). This is consistent with national biodiversity Action Plans and with National Sustainable Development Strategies, which DFID is taking a lead role in developing and implementing.
- Support the decentralisation of agricultural research and extension services, including plant breeding.
- When required, invest in 'smart' emergency seed distribution that is tailored to specific local agro-ecological, economic and social conditions.
- Assist countries to implement intellectual property protection as required under the WTO/TRIPs agreement, in a way which is consistent with other national priorities such as the maintenance and sustainable use of agricultural biodiversity.
- Support strengthening of coordinated approaches by all relevant ministries and agencies in international negotiations, especially FAO, the CBD and WTO, which may involve capacity building for negotiators at country level.

c) Global level

- Promote managing agricultural biodiversity for poverty reduction and development, and mainstreaming biodiversity issues, in multilateral financial institutions and other multilateral agencies (e.g. World Bank, IFAD, and regional development banks).
- Fund research into how local and global agricultural biodiversity objectives can be reconciled.
- Advocate regular re-assessments of the global agricultural research framework under the CGIAR system, to ensure its continuing responsiveness to developing countries' needs.
- Invest in development education, including raising consumer awareness of biodiversity-friendly agricultural production systems.
- Work for the successful outcome of the revision of the International Undertaking on PGRFA, and promote its eventual implementation in ways which will benefit small farmers as well as the international community.
- Ensure that the "farmers' exemption" is protected in any international agreement on patents

or plant breeders rights (plant variety protection).

- Use DFID's international influence to promote the implementation of the FAO Global Plan of Action and CBD/CoP Decision 3/11, supported by appropriate financial mechanisms.

d) Policy consistency

Ensure trade policy, (including intellectual property protection and the UK's stance on TRIPs), agricultural support policies, research and development policies etc are supportive of using agricultural biodiversity to support sustainable livelihoods.

Chapter 1. Agricultural biodiversity

1.1 What is agricultural biodiversity?

Agricultural biodiversity encompasses 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 for, and in support of, food production and food security[1].

Table 1.1 sets out the biological scope of agricultural biodiversity in more detail.

Table 1.1 Scope of agricultural biodiversity by biological taxa

Taxa	Scope
Plants	• Crops • Harvested and managed wild plants for food • Trees on farms • Pasture and rangeland species
Higher Animals	• Domestic animals • Wild animals • Wild and farmed fish
Arthropods	• Pollinators (e.g. bees, butterflies) • Pests (e.g. grasshoppers, greenflies) • Predators (e.g. wasps, beetles)
Soil biota	• Organisms (e.g. earthworms) • Microbes (e.g. rhizobia, fungi, disease-producing pathogens)

This paper focuses on the underlined components.

Many people say that local knowledge and culture are also integral parts of agricultural biodiversity, because it is the human activity of agriculture which conserves this biodiversity. 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[2]. 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, since Mendel's work on genetics, 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.

Agricultural biodiversity is essential to the world for three main 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;
- ecological services provided by agro-ecosystems, such as landscape protection, soil protection and health, water cycle and quality, air quality.

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

1 Adapted from FAO, 1999.
2 The information in this paragraph is taken from Lenné, 1999:2-4.

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 of agricultural biodiversity, its **conservation 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.

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 the other components of agricultural biodiversity are also crucially important for sustainable agriculture. The biodiversity of insects, fish, forests, livestock and wildlife are dealt with in companion papers. 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).

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, minerals, etc. But there is a lack of knowledge outside the communities concerned 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 selection and selection by humans. In crop agriculture, for some species this selection has led to the development of many thousands of 'landraces' or 'farmers' varieties'.

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

1.2.2 'Wild' plant biodiversity

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 supply useful genes through natural or artificial introgression. Genes for specific traits are sometimes transferred by cross-pollination between non-specific wild relatives and crops. 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 to be 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 the contribution of roots to soil organic matter in tropical systems is also 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.

Understanding the determinants of root architecture of food crops could enable rapid development of farmer participatory research into the deeper placement of organic manures and fertiliser, in pits or trenches, to synchronise water and nutrient requirements for crops in potentially drought-stressed systems. There is also some evidence that the deeper development of feeder roots is effective in reducing Striga infestation of maize.

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4 Summarised from Professor J M Anderson, pers. comm. September 1998.

1.2.4 *Microbial biodiversity in agriculture*[5]

Microbial biodiversity has been neglected over the years but is now a topic of global attention, following the realisation that microbes harbour a wealth of gene pools that could be a source of material for effective cloning and expression in plants to achieve traits such as stress tolerance and pest resistance. Micro-organisms have an important role in plant biomass recycling, gene transfer and expression, 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 fixation or ecto/endomycorrhiza. Seed-borne microflora are instrumental in seed transmission of disease and thereby important in plant quarantine. They also produce varied mycotoxins thus affecting crop production and utilisation. 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 at ecosystem level*

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 and the 'agro-ecosystems approach' to agricultural biodiversity conservation as promoted by the Convention on Biological Diversity[8].

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5 Summarised from Srinivasan (1998).

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 CoP Decision III/11, and as elaborated in the latest international workshop on the CBD multi-year programme of work on agricultural biodiversity (FAO, 1999).

An ecosystem consists of the variety of different species and their interactions with each others, within a defined spatial complex. These interactions can be on an individual basis, competitively or symbiotically. 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.

Ensuring that agricultural biodiversity is maintained within the agro-ecosystem makes important contributions to all its main functions outlined in Section 1.1:

- 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[9]. The interaction between the environment, genetic resources and management practices that occurs 'in-situ' within agro-ecosystems ensures a dynamic portfolio of agricultural biodiversity is maintained. At the local level, it results in genetic material (landraces or animal breeds) that are adapted to the local abiotic and biotic environmental variation, as well as being 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 where traditional-type agriculture still predominates, agricultural biodiversity remains a significant provider;
- ecological functions: valuable ecological processes that result from the interactions between species and between species and the environment include the maintenance of soil fertility and water quality and climate regulation (e.g. micro-climates caused by different types and density of vegetation).

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[10]. 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.

1.3 Agricultural biodiversity in different agricultural systems

The mix of plant, arthropod and micro-organism agricultural biodiversity at the species and genetic level varies in different ecological systems according to the natural conditions of altitude, rainfall and temperature. However, we have already seen that there is also a close interdependence in the relationship between people and agricultural biodiversity. Thus, the potentialities of agricultural biodiversity in any one agro-ecosystem are determined by a matrix of 'human' factors and feedback loops in addition to the underlying natural conditions.

[9] Conservation strategies are discussed further in Section 2.3.
[10] For more on the debate concerning ecological stability in agro-ecosystems and the contribution of agricultural biodiversity to this, see Conway (1997) and Thrupp (1998) versus Wood (1998).

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 (production of a wide range of food crops, fodder, medicine, building materials, etc) Their emphasis may be on risk avoidance or minimisation, rather than on maximising production. All 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, and the key requirement is to enable them to continue to do this.

In contrast, agricultural systems that are more ‘industrial’ are heavily integrated into the market system. Farmers in industrial-type systems 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, i.e. 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 Chapter 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.

The factors determining levels of agricultural biodiversity in production systems are:

- underlying ecological conditions;
- farmers skills in on-farm agricultural biodiversity management;
- farmers access to useful agricultural biodiversity off-farm (neighbours, adjacent wild areas, formal sector plant breeders)[11] (which is partly determined by connectedness, population pressure, communications, etc.);

[11] In this paper, ‘formal sector’ refers to scientifically-trained staff working in government, private, and voluntary sector institutions.

- 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.

So, thus far, we can see the important functions and services provided by agricultural biodiversity at the ecosystem level across all ecosystems, scales, and production systems; the fact that there is not a simple correlation between ecosystem, agricultural system, and levels of agricultural biodiversity; and we can see that a complex matrix of human factors determine the potentialities for using agricultural biodiversity for sustainable livelihoods in any one agro-ecosystem.

Chapter 2. The management of agricultural biodiversity

In more traditional-type agricultural systems, agricultural biodiversity is 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. Pest control may be mediated primarily through cultural practices and natural enemies. 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. Nutrient cycling is often supplemented by bought-in fertilisers, and pest control is often managed though the use of pesticides, though increasingly integrated pest management (IPM) strategies are being used.

Agricultural biodiversity conservation is discussed in Section 2.3.

2.1 Farmer management of agricultural biodiversity[12]

Farmers view agricultural biodiversity from an agro-morphological viewpoint. In their review of studies of on-farm management of crop diversity, Wood and Lenné (1993) report that farmers use agro-morphological characters as markers for taste, texture, yield, storage characters, resistance to environmental stresses, use and maturity time, and that remarkable parallels exist across crops, cultures, and continents.

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 more or less uninfluenced by 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 communities with a strong cultural identity and a highly varied agro-ecology, such as the highlands of Sierra Leone, 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.

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[12] For more on this, see Bellon, 1996; Jarvis and Hodgkin, 1997; and, Cromwell and van Oosterhout, 1999.

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 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 in order 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 landrace 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.[13]

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 yield more in response to applications of chemical fertiliser; or which incorporate resistances to pests and diseases thus reducing 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 MVs. 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 result 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: dangerous susceptibility of the national crop to outbreaks of pests and diseases and abnormal weather conditions. 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 vunerable.

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

13 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.

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:

- 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[14]

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 have been 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;
- public health side effects from the widespread use of antibiotics as marker genes, which may lead to the spread of resistant bacteria (although the quantities involved would be comparatively small and in any case, in response to public concern, future transgenics will no

14 For more on this see Tripp, 1999.

longer have such genes [Witcombe, pers. comm. November 1998]);

- 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.

Shantharam (1997) states that even bodies such as the United States Department of Agriculture admit gene escape has been demonstrated and that questions remain regarding the long-term effects of growing transgenic crops in monoculture and the associated changes that might occur in agricultural practices. At present there are no useful working models with predictive value on which to base environmental risk assessments of the impact of genetically engineered organisms on biodiversity (ibid.). The regulatory framework for the development and use of transgenic crops is currently under negotiation in the Convention on Biological Diversity's BioSafety Protocol.

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[15]. 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

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

and losses of the wild foods that are essential for food provision.

Table 2.1 Two approaches to management of agricultural biodiversity

	Static Diversity	Dynamic Diversity
Explanation	Biodiversity is 'frozen' in time. Seeds are conserved outside their natural environment (ex-situ), often without accompanying socially disaggregated data that identifies their utilisation potential	Biodiversity is dynamically changing and increasing over time in response to new production challenges. Utilisation ensures interaction between farmers, their varieties and the environment *(*in-situ*)* leading to constant development of the resource
Perception	Biodiversity is seen in terms of numbers of accessions	Biodiversity is seen as a web of relationships that ensure balance and sustainability
Location	Genebanks, databases	Fields, forests, rangelands, farmers' knowledge
Actors	Scientists, administrators	Farmers, indigenous people and their communities
Mode of operation	Conservation through collection, annotation and storage	Conservation through use: seeds develop through farmers' selection in current growing conditions; farmers' knowledge increases
Focus	Main crop staples and plants with large commercial potential	A wide variety of crops and plants that ensure local food and livelihood security
Drawbacks	Only effective if set up with the help of farmers and indigenous peoples and their communities Seeds saved may not be farmers' choice Seeds cannot adapt to changing environmental conditions Seeds may die in storage	Varieties may be lost if they are not useful to communities, but genes may survive through crossing into new varieties Seed stores and associated knowledge are decentralised and difficult to access Conservation strategies are complex and diverse, therefore difficult to manage Conflict, natural disasters and economic pressures may cause catastrophic losses
Advantages	Easy access and well documented collections Saves seeds with no immediate apparent use or value Easy to establish 'blueprint' models for conservation Provides essential back-up when all in-situ seeds have been lost through unforeseen disasters	Incentive for conservation is great because livelihoods depend on it Seeds adapt to changing environmental conditions and needs Much larger gene pool and knowledge base to draw on Seed supplies are safeguarded by communities, through diverse production systems

Source: ITDG, 1996: 6

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.

Although millions of farmers around the world use, manage and develop agricultural biodiversity

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

on a practical, daily basis, the governance of its conservation, sustainable use and benefit-sharing is affected by a number of agreements negotiated and implemented at the international level – particularly the *Convention on Biological Diversity*, the *Global Plan of Action for the Conservation and Sustainable Use of PGRFA*, and the WTO agreement on Trade Related Intellectual Property Rights[17]. These agreements already have a significant impact on agricultural biodiversity world-wide, and their influence is likely to increase over time as further global agreement is reached about the way forward for conservation, sustainable use and benefit-sharing.

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'.

It is now realised that this approach is valuable but insufficient alone for at least three reasons:

- it is relatively expensive and risky. For example, seeds in gene banks are generally stored in cool conditions, which requires special equipment dependent on power supplies: if there are power failures, the seeds can be irretrievably damaged;
- gene banks cannot 'store' the farmers' knowledge and experimentation that creates and maintains agricultural biodiversity, so this vital dynamic component of agricultural biodiversity is missing in gene banks;
- it is often very difficult for ordinary farmers to obtain seeds from gene bank collections, as the individual seed samples are usually small (the seeds are not intended for general distribution), and the gene banks may be far away.

So instead of relying only on conservation in gene banks (often referred to as ex-situ conservation), many people now promote 'conservation through sustainable use' in farmers' fields (also referred to as in-situ or on-farm conservation). 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 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[18], and – as we shall see in Chapter 5 – there are various ways of creating an enabling environment for on-farm conservation. There may also be a role for the protected area (PA) approach in, for example, providing ecosystem services that have a direct link to maintaining high biodiversity farming techniques. For example, in Costa Rica citrus plantation farmers pay PA authorities a small premium for ecosystem services provided to plantations surrounding the PA, leading amongst other things to a much lower incidence of leaf scale virus in plantations around PAs (Koziell, pers. comm. January 1999).

Indeed, most recently, people have recognised that in-situ or on-farm conservation should take into consideration the whole ecological system in which farmers are farming. This is because agricultural biodiversity includes not only genetic and species diversity but also diversity in ecosystems as a whole[19].

Whilst some efforts are made to protect endangered species of plants and animals, in the case of other components of agricultural biodiversity no realistic estimates exist for the loss of valuable germplasm and gene pools under natural conditions. For example, pure culture isolation and conservation of microbes in well-established culture collections appear to be the only solution to

17 These are outlined in Appendices 1–3.
18 See, for example, Altieri and Merrick, 1987; Bellon, 1996; Louette et al., 1996; Cromwell and van Oosterhout, 1999.
19 For more on the ecosystems approach, see FAO, 1999.

ensure protection of microbial species, particularly the rare forms, from extinction. The key requirements at present are the identification and isolation of different taxa by innovative screening of natural resources, effective conservation *in vitro* to ensure long-term survival and genetic stability, and mutation and strain improvement to enhance yields of desirable metabolites through the application of classical genetic approaches.

A recent NGO briefing sheet, reproduced in Table 2.1, summarises the main differences between existing conventional ('static') conservation approaches and the type of ('dynamic') conservation approaches that are increasingly promoted in international agreements.

Chapter 3. Valuing agricultural biodiversity

3.1 Stakeholder groups

3.1.1 Direct stakeholders

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

- **Multi-nationals**, including a diversity of agro-chemical, food, and medical companies in developing and developed countries. These are mainly concerned to profit from using agricultural biodiversity, which means they are keen to protect the return on their huge 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 environmentally-friendly products. In the North, the latter two concerns are leading to a growing market for organic and 'footprint' food (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 sometimes incorporating technologies such as transgenic crops – around which there are some safety concerns. 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, either through Plant Breeders Rights and other components of national seeds laws (particularly for public sector breeders), or through intellectual property protection such as patents.
- **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. The main concern of this group is to ensure 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 farmers, 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.

3.1.2 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[20]

Table 3.1 outlines the various values of agricultural biodiversity.

3.2.1 Direct use values

Direct uses of agricultural biodiversity include having a range of products; and the nutritional contribution (provision of minerals, vitamins and protein; hunger crops).

3.2.2 Indirect use values

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-

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

Table 3.1 Agricultural biodiversity values

CROPS	WILD PLANTS	SOIL BIOTA
DIRECT USE VALUES		
Farm livelihoods		
Quantity and quality of food	Micro-nutrients	
Food preferences	Famine foods	
Animal fodder	Cash income	
Building/fencing materials		
Cash income		
Genetic enhancement		
Crop breeding	On-farm and formal sector crop breeding	Crop breeding through gene transfer
Food additives	Food additives	
Other		
Medicines		
Amenity		
INDIRECT USE VALUES		
Production		
Storability		Plant biomass recycling
Yield stability		Gene expression
Pest/disease resistance		Plant metabolites
Root effects (nutrient +water uptake, soil stabilisation, disease resistance)		
Ecosystem functions		
Ecosystem productivity	Ecosystem productivity	Ecosystem productivity
Soil quality	Soil quality	Soil quality
Water cycle and quality	Water cycle and quality	Water cycle and quality
Micro-climate (shade, etc)	Micro-climate (shade, etc)	Micro-climate (shade, etc)
Macro-climate (carbon cycle, etc)	Macro-climate (carbon cycle, etc)	Macro-climate (carbon cycle, etc)
Habitat protection (for other components of biodiversity)	Habitat protection (for other components of biodiversity)	Habitat protection (for other components of biodiversity)
NON-USE VALUES		
Existence		
Intrinsic value		
Cultural (festivals, celebrations)		
Option		

ecological requirements.

Swanson et al., (1993) also identify the 'portfolio value' of agricultural biodiversity for smoothening yield variability through the maintenance of a wide portfolio of crop diversity (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.

3.2.3 'Non-use' values

These include existence value and 'option value'; the potential of agricultural biodiversity to provide economic benefit to human society in the future. Swanson et al., (ibid) identifies 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.

3.2.4 Protection, sustainable use and conversion

The uses of biodiversity are often classified into three categories: protection, sustainable use, and conversion. For other components of biodiversity, such as forests or wildlife, these use categories are often considered to be mutually exclusive, such that trade-offs between them are inherent: you can choose either to protect a piece of primary rainforest, or to convert it to another land use, but you can't do both at once.

We suggest that this is not the case for agricultural biodiversity. Firstly, sustainable use is the main means of protecting agricultural biodiversity i.e. these two categories are intimately connected. Secondly, agricultural land is not 'converted' from biodiverse to non-biodiverse: in all agricultural systems, farmers maintain a 'portfolio' of crop and livestock species and breeds, wild resources, insects, and soil organisms, which may be more or less diverse but not non-diverse. The level at which 'conversion' may be an issue in relation to agricultural biodiversity is the agro-ecosystem level.

* * * *

To date, stakeholders using agricultural biodiversity directly for sustainable livelihoods (farmers in traditional- and industrial-type agriculture, providers and users of traditional medicine) have been near the bottom of the heap in terms of voice and market power, whilst stakeholders with an interest in controlling access to agricultural biodiversity in order to capture its value have been much more powerful. Thus, 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 are more biodiversity-friendly. The obvious example of this is the widespread uptake of IPM techniques in the intensive rice zones in South and south-east

Asia;

- the increasing voice of consumers demanding ecologically-friendly agricultural production processes;
- 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 stakeholders shows the potential for capturing economic rents on agricultural biodiversity, due to the unequal voice and market power of the different stakeholders. Secondly, the analysis points to the inevitability of conflicts between the vastly differing interests of different stakeholders in agricultural biodiversity, exacerbated by their dramatically different degrees of effective voice and market power. This in itself points towards the importance of treaties for reaching agreement on agricultural biodiversity issues. Finally, non-market uses of agricultural biodiversity (for example, the provision of ecosystem services and functions) have had few direct stakeholders, who have tended to be weak, and this raises questions concerning whether sufficient value has been attached to these functions and services in the past.

3.3 Approaches to valuing agricultural biodiversity

There are still significant gaps in the scientific understanding of agricultural biodiversity which affect its economic valuation.

3.3.1 Indirect use values

Some *ecosystem services* can be valued relatively straightforwardly (e.g. wild insects pollinating crops can be valued at the incremental value of the crop, or the cost of hiring honey bees), whilst others are much harder (e.g. CO2 absorption by plant communities). Generally, the value of ecosystem services is inadequately captured using conventional economic analysis, as we shall see below.

3.3.2 'Non-use' values

Existence (for biological communities, or areas of scenic beauty) 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.

3.3.3 Direct use values

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. But this approach may not be sufficient for some components of agricultural biodiversity, especially crop diversity, which can generate improvements in yields valued at far beyond its market sale price. 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). Appendix 4 discusses the valuation of crop diversity in more detail.

3.4 Trade-offs, conflicts and synergies in valuing agricultural biodiversity

When agricultural biodiversity was free access, the economic framework for analysis was simple (although implementation was not): agricultural biodiversity is a public good and society should spend on conservation a sum such that the marginal cost of an additional effort is equal to the marginal value of the amount of resources saved through the additional effort.

But 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. Thus, in relation to the utilisation of agricultural biodiversity, the key choices and trade-offs relate to benefit-sharing and the resulting incentive structures for utilisation efforts: how to assess and value agricultural biodiversity, who to compensate, and how. The current international position on these issues is outlined in Appendix 1.

Policy choices are made more difficult at all levels by the fact that national policy makers often lack the technical and economic base on which to build coherent policies, and are uncertain as to how to manage agricultural biodiversity issues at the interface with international fora. Furthermore at the global level, different stakeholders are unable to reach mutually agreeable definitions of issues and resolutions of conflicts in the many international fora that exist for negotiating agricultural biodiversity conservation, use and benefit-sharing.

For agricultural biodiversity, apportioning the value of the final product among the complementary inputs is difficult (see Box 3.1) but critical for both efficiency and equity. This is influenced by:

- the economic stakes; and,
- the regulatory framework for access and benefit sharing (which is a political process influenced by the relative strengths of the stakeholders involved).

Box 3.1 Fair shares for stakeholders?

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;
- their 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 various 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.

Source: adapted from Swanson et al., 1993

When knowledge was a public good, free access to agricultural biodiversity was probably the regime ensuring the greatest research effort, and the benefits of this effort were more-or-less accessible to all.

With knowledge becoming a private good, free access to agricultural biodiversity will inevitably result in the benefit of research being appropriated by the owners of IPRs. The ‘owners’ of the agricultural biodiversity (for the sake of argument, the countries of the South) will be at a disadvantage in striking a better bargain for themselves because they do not really know how to determine the ‘value’ of their agricultural biodiversity. Benefits could be assessed after a new crop variety has been sold on the market, but there is no *a priori* principle to decide how to share benefits, and the information available to the owners of agricultural biodiversity and those who have knowledge is so asymmetrical that there will inevitably be moral hazard.

In relation to agricultural biodiversity conservation, this remains essentially a public good even if private initiatives contribute to it. The key choices and trade-offs here are: how much conservation should there be, where and how (ex-situ vs in-situ), at what cost, and how to finance it (public vs private sector).

It is hard to predict the effects of technical change and market demand on the future value of agricultural biodiversity. A global regulatory framework is needed to ensure the values of agricultural biodiversity are fully captured at each level in the stakeholder hierarchy i.e. by internalisation of some values that are currently global public goods (although some, such as ecosystem functions, will always remain public goods, and here the emphasis should not be so much on capturing the benefits, as on ensuring stakeholder activities do not generate global bads).

Chapter 4. Relationship between agricultural biodiversity, poverty and development

4.1 Agricultural biodiversity and sustainable livelihoods

Figure 4.1 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:

- agricultural production, in both traditional and industrial-type agricultural systems, is predominantly for productive use, but also for ecosystem functions and services;
- consumption may be for productive use value (sold on the market) but consumptive use is also important – especially for poor people who rely on agricultural biodiversity to provide goods they cannot buy on the market (fuel from crop stoves, thatching grass gathered from field margins and wild areas, traditional medicines, etc);
- conservation is both for productive use now and for option and existence value for the future. In traditional-type agricultural systems, much of this will be carried out on-farm; in industrial-type agricultural systems and for global stakeholders, such as international agricultural research and multi-national agro-chemical companies, this is carried out in ex-situ gene banks and breeders' working collections.

Agricultural biodiversity 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 indirectly 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).

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.

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

Table 4.1 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 4.3 and Chapter 5. As we saw in Section 1.3, there is a matrix of factors determining the exact portfolio of livelihood strategies used by any one farmer, so the exact contribution of agricultural biodiversity will vary according to the precise circumstances.

Figure 4.1 Agricultural biodiversity & sustainable livelihoods: A framework

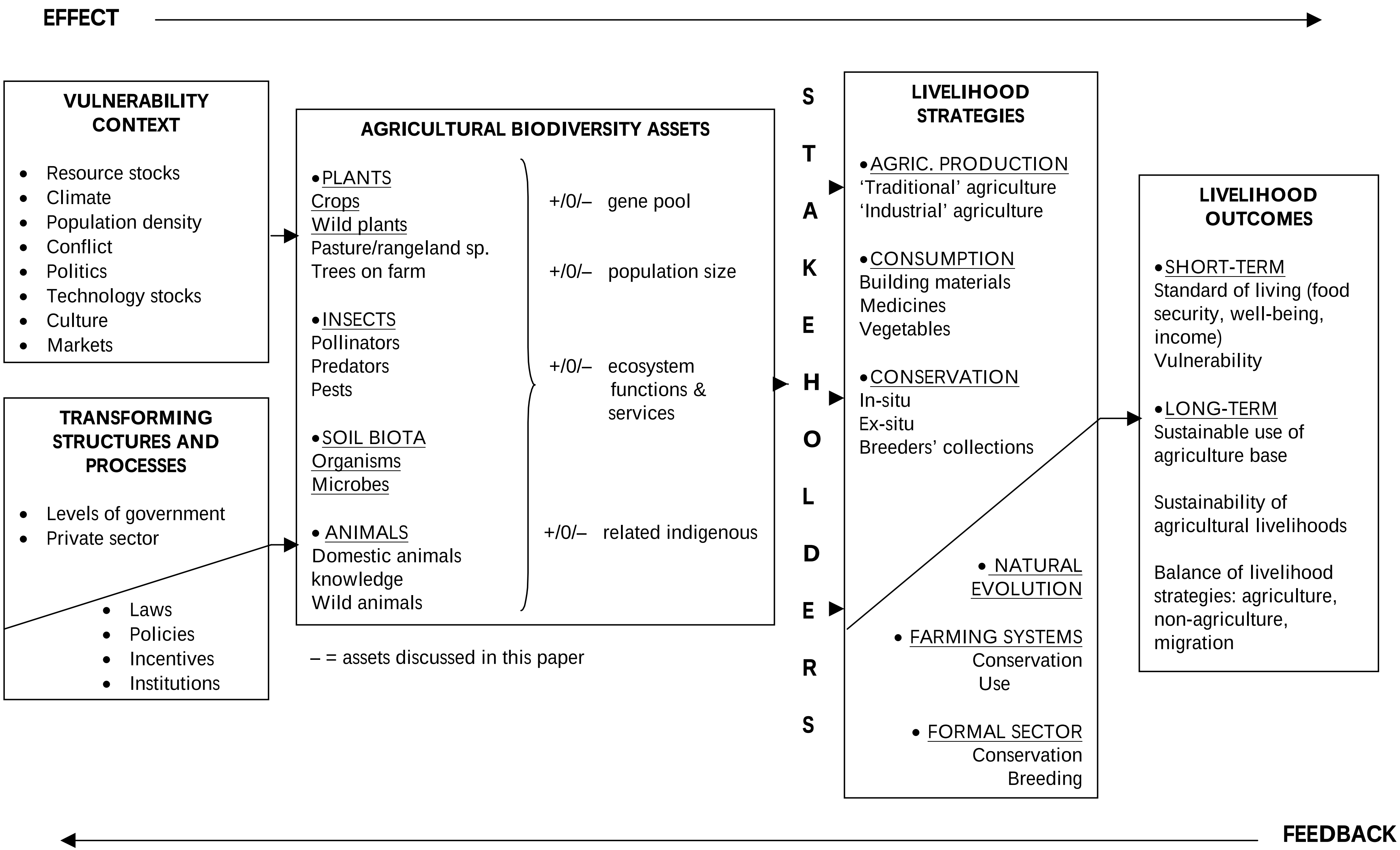


Table 4.1 Agricultural biodiversity and different stakeholders' livelihoods: a typology

Stakeholder	Contribution of ag. biodiversity to sustainable livelihoods	What kind of agricultural biodiversity?	Supportive approaches
Farmers in 'traditional'-type agriculture	• Basis of sustainable food production & livelihood systems	• Plant, animal, arthropod & soil biota on-farm: • genetic diversity • ecosystems diversity • related human knowledge	• Strengthen farmer/community management of ag. biodiversity • Increase ag. biodiversity options available to farmers
Vulnerable groups in rural & peri-urban areas	• Significant contribution to nutrition & other livelihood needs	• Specific components (wild foods, harvested weeds, NTFPs)	• Protect local rights to public access ag. biodiversity
Farmers in 'industrial'-type agriculture	• Raw material for formal sector plant breeding to increase yields	• Plant genetic resources off-farm[21]	• National protection of ex-situ conservation & of access to plant genetic resources through formal sector plant breeding
	• Ecosystem functions & services	• Non-crop ag. biodiversity on- and off-farm (soil biota, etc)	• Promote integrated crop management
Global stakeholders (consumers, scientists, country groupings)	• Sustainable food production for all (Northern & Southern producers & consumers)	• Global: • genetic diversity • ecosystems diversity • related human knowledge	• Support ex-situ and in-situ conservation of ag. biodiversity globally
	• Access to ag. biodiversity for breeding & manipulation by scientists	• Global: • genetic resources • related human knowledge	• Promote access to ag. biodiversity through appropriate international agreements • Ensure access to enabling technologies

Notes:
* NTFPs = non-timber forest products
* The concept of traditional-type and industrial-type agriculture is explored more fully in Section 1.3.
* Possible supportive approaches form the content of Chapter 5.

4.2 Agricultural biodiversity, conversion and poverty

There are two knotty 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 biodiverse agriculture?

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

[21] If appropriate infrastructure exists for ex-situ conservation and delivery of formal sector plant breeding results.

developed countries; and 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 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 (e.g. 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.

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 under current economic conditions it spreads performs better or risk better than the alternatives currently available 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 & van Oosterhout, 1999; Brush, 1988). On the other hand, there are also clear cases of 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-farm and off-farm livelihood activities. Loss of this biodiversity can be associated with heavy livelihood losses through undermining their production choices, and 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 the need to work with local farmers and communities in a participatory manner to identify opportunities for action and the most appropriate means of implementing them.

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 (for example, input subsidies, agricultural extension messages, or widespread distribution of modern seeds in emergency relief packages). And for politically, economically and socially marginalised groups, protection, maintenance of, and improved access to, agricultural biodiversity can often contribute more to sustainable livelihoods than can conversion, as their traditional entitlements to agricultural biodiversity may be stronger than their market access to agricultural production inputs. Note 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).

So it is therefore highly inappropriate to promote large-scale abandonment of biodiverse agriculture and 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.

> There is huge inertia in perceptions and beliefs – and vested interests – in favour of continuing to promote conversion of biodiverse agriculture but 'Given a world economic system in which millions of children die each year from disease, malnutrition, crime, and war, and in which thousands of unique species go extinct each year due to habitat destruction, do we need to make minor adjustments or major structural changes?
>
> *Source*: Primack, 1993:236

* * * *

So far, this Chapter has explored the relationship between agricultural biodiversity, poverty and development, and in the process has highlighted that:

- agricultural biodiversity can make a valuable contribution to sustainable livelihoods for numerous stakeholder groups; and,
- there are various entry points for changes to be made to allow the contribution of agricultural biodiversity to sustainable livelihoods to be optimised in traditional-type agricultural systems, industrial-type agricultural systems, and for other stakeholders.

4.3. 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 contributes to the 'dynamic' management of agricultural biodiversity. This involves:

- cross-sectoral action (agricultural biodiversity issues have relevance to more than 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 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).

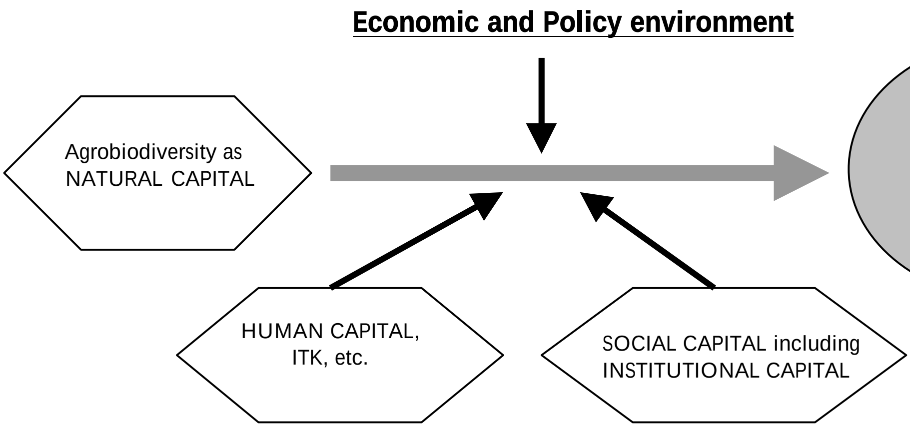
It is essential to break down the economic incentives, institutional and policy barriers that currently exist against using agricultural biodiversity sustainably, by correcting the current policy, research and implementation inertia pulling towards the industrial-type agriculture model.

Clearly, this new approach to agricultural biodiversity fits well with DFID's sustainable livelihoods objectives. Agricultural biodiversity is often viewed as a resource stock that can be drawn down upon 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'.

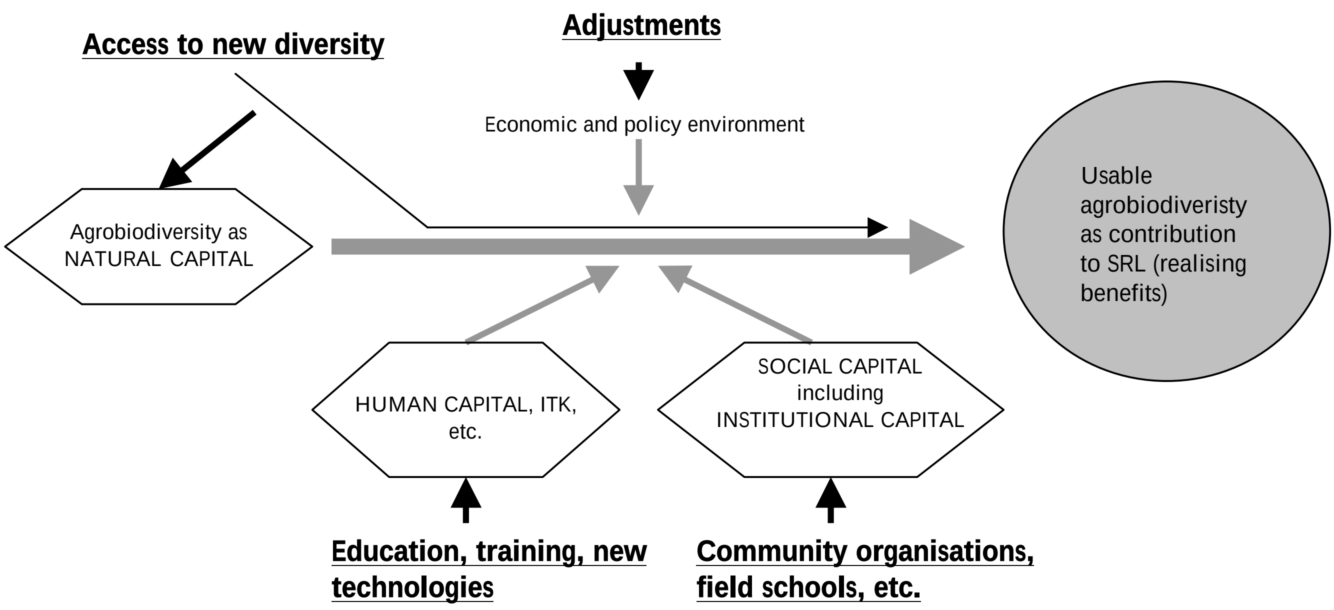
Earlier sections have demonstrated the role of traditional-type agricultural systems and technologies in managing agricultural biodiversity. Care should be taken not to undermine these traditional approaches nor to sweep away unnecessarily the agricultural biodiversity on which they are based. But a purely conservationist approach must also be avoided: farmers in traditional

Figure 4.2 A framework for using agricultural biodiversity to support sustainable rural livelihoods

1 The main objective: to use agrobiodiversity to contribute to sustainable rural livelihoods



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



3 Entry points to strengthen ability to use agrobiodiversity 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.

farming 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, as well as promoting integrated pest management which relies on the biodiversity of natural enemies of pests, etc. 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.

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 Chapter will explore these entry points. Note that there is already an international mandate for nearly all these actions – local, national and global – in the form of the Decisions on agricultural biodiversity agreed by the Conference of the Parties (COP) to the Convention on Biological Diversity (see Appendix 2) and the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (see Appendix 3).

Box 4.1 Effects of interventions on agricultural biodiversity

The effects of livelihood strategies on agricultural biodiversity are difficult to predict in general terms, because there is no clear-cut causal relationship between agricultural biodiversity and poverty, which depends on numerous factors. In some situations, development will result in biodiversity reduction on-farm. In others, the only viable livelihood strategies will be dependent on managing and maintaining agricultural biodiversity. A good working knowledge of the local situation, for example through agricultural biodiversity assessments, is required before outcomes can be realistically predicted.

In addition, it is important to remember that the effects on agricultural biodiversity should not necessarily be compared with the status quo, but with the most likely baseline scenario. For example, the effects of participatory plant breeding on crop diversity in a farmer's field may result in a decrease as compared to the status quo, but an increase as compared to the most likely baseline activity of introducing uniform varieties.

In conclusion, the best approach might be to pursue local level opportunities which use agricultural biodiversity on the basis that they strengthen rural livelihoods and reduce poverty. Where possible this might be accompanied by monitoring of the effect on agricultural biodiversity. Opportunities to enhance positive effects and mitigate negative effects should be taken. Where multiple options exist for strengthening rural livelihoods, then the approaches which have the greatest positive or least negative effect on agricultural biodiversity might be taken.

Chapter 5. Using agricultural biodiversity to reduce poverty: policy options & entry points

5.1 Agricultural biodiversity in DFID operations

> "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

There are a number of specific entry points for DFID to support the use of a wide range of agricultural biodiversity for poverty reduction, development and food security, in individual country programmes; in DFID's participation in global fora and negotiations; and in DFID's role in ensuring policy consistency across the UK government in relation to poverty elimination.

5.1.1 Individual country programmes

At the individual level, country strategy papers (CSPs) cover sustainable livelihoods (including all natural resources), health and population, and social development (including education) – although interestingly there is no specific agricultural biodiversity component in CSPs at present. Given the important potential contribution of agricultural biodiversity to sustainable livelihoods, this should be remedied.

Since the 1997 White Paper, CSPs have been guided by preparatory sustainable livelihood missions, which set out DFID's entry points for supporting sustainable livelihoods in each country. These, too, to date do not include specific consideration of the agricultural biodiversity context in each country – which needs to be corrected.

In DFID's NR focus countries, the CSP is complemented by a renewable natural resources sector paper. This does not include statements of the country's needs to support conservation and sustainable use of agricultural biodiversity and, again, this needs to be addressed.

DFID has designated Brazil, Indonesia and Mexico as global environment countries, where biodiversity resources are of global significance. In these countries, DFID's actions in support of the sustainable use of biodiversity do not have to be directly poverty focused.[22]

In addition to DFID's country programmes, there is the separately managed Renewable Natural Resources Research Strategy. On account of its size and influence, it is essential that research activities themselves and research outputs under the RNRRS are supportive of using agricultural biodiversity to reduce poverty. The award of research funds by the eleven individual programmes that comprise the RNRRS is guided by country framework papers, so it is essential that these country framework papers are supportive of the principle that agricultural biodiversity can be used to reduce poverty.

DFID's Joint Funding Scheme (and its successor in due course) is the Department's major vehicle for supporting the activities of non-governmental organisations and, as such, should also be supportive of the principle that agricultural biodiversity can be used to reduce poverty.

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22 DFID has also identified biodiversity target countries, but this categorisation is not used in practice to guide country programmes.

5.1.2 *Global level*

Much of the work in this area is carried out by the EU on behalf of member states; other aspects of the work are implemented through DFID's Global Environmental Assistance Facility under the Environment Policy Department.

DFID represents the UK in a number of international institutions including the Global Environmental Facility (GEF) and the Consultative Group on International Agricultural Research (CGIAR). It also participates in international negotiations concerned with the revision of the FAO International Undertaking on Plant Genetic Resources, and in the Conference of the Parties to the Convention on Biological Diversity, including its Working Group to develop a BioSafety Protocol.

However, many individual developing countries need capacity-building and financial support to participate in international processes such as the CBD negotiations on agricultural biodiversity. An important issue is therefore whether DFID should invest at national level to help international processes, and whether this should be through geographical funding or through GEAF.

5.1.3 *Policy consistency*

With the creation of DFID in May 1997, the new Department assumed a role in ensuring consistent policies across the UK government in order to promote poverty elimination. The logical consequence of this policy consistency role is that DFID should aim to ensure that trade policy, including intellectual property protection and the UK's stance on TRIPs, agricultural support policies, research and development policies etc are all supportive of the approach outlined above for using agricultural biodiversity to support sustainable rural livelihoods.

* * * *

The rest of this Chapter outlines the ways in which agricultural biodiversity can be used for poverty reduction, development and food security across the spectrum of stakeholders. At the end of each section, the key entry points for DFID are prioritised and summarised in a Box. Note that these are the *priorities* for DFID extrapolated from the general discussion and range of entry points outlined in each section.

In addition to these practical actions, there is also a need to raise the profile of the conservation and sustainable use of agricultural biodiversity in DFID's internal guidelines. These are summarised in Box 5.1.

Box 5.1 Suggested modifications to DFID guidelines in support of using agricultural

Sustainable Livelihood missions:	• include specific consideration of agricultural biodiversity context and opportunities for using ag. biodiversity for sustainable livelihoods
Country Strategy Papers:	• include agricultural biodiversity component
NR sector papers:	• include statements of country's needs to support conservation and sustainable use of ag. biodiversity
RNRRS:	• include research on agricultural biodiversity as an SL 'capital asset'; ensure country framework papers are supportive of using agricultural biodiversity for sustainable livelihoods
Joint Funding Scheme:	• should be supportive of using agricultural biodiversity for sustainable livelihoods
EPD GEAF:	• consider investing at country level to help international processes
Policy consistency:	• ensure all UK policies are supportive of using agricultural biodiversity for sustainable livelihoods

5.2 Local level

In all typical regular aid interventions at the local level there are opportunities to use agricultural biodiversity to contribute to sustainable livelihoods. These opportunities are summarised in Table 5.1 and discussed below. It is important to realise that they constitute much more than using crop genetic resources to breed varieties which will increase agricultural productivity, and that they relate to all agricultural biodiversity stakeholders, including farmers in industrial-type agricultural systems as well as those in traditional-type agricultural systems. They build upon farmers' own efforts and existing management systems by action to support the wider use of agricultural biodiversity to reduce poverty, promote development, and improve food security.

5.2.1 Access to and better management of natural resources

<u>Agricultural biodiversity conservation</u>

Existing agricultural biodiversity has to be conserved in order to ensure access to it now and in the future. Because agricultural biodiversity is a product of human management as well as natural genetic resources, its conservation must necessarily involve people. 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 oda, but from non-aid sources, such as the Global Environmental Facility.

Measures which may be promoted 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	
	Developing local markets for biodiversity-friendly ag. products	Tharaka-Nithi farmers project, Kenya
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
UK policy consistency		

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

Access to germplasm

The conservation of agricultural biodiversity makes no 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;
- 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.

Two examples are illustrated in Box 5.2.

b) Improved linkages with the formal seed sector

- Promoting the idea of the national genebank 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).

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 are more reliant on seed of local farmers' varieties, may also face problems of poor physical quality (especially if local environmental conditions support seed pests and diseases in field or in store), and short supply. One solution is to provide technical back-stopping to local level seed multiplication, e.g. promoting farm or village level seed production enterprises focusing on producing quality seed. This has the added advantage of potentially becoming a local level income-generating business. One constraint can be the obligation to comply with cumbersome and expensive national seed quality standards, usually originally developed for large-scale mechanised seed production and processing operations producing seed for 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 5.30) may be

Box 5.2 Farmer-to-farmer seed exchange mechanisms

Seed banks

- ***De facto* seed banks** – the sum of all seed storage in a community. They have been existence for a long time, operate informally, and are made up of individually stored, locally multiplied, farmers and modern varieties of seed, kept in individual households.
- **Ceremonial seed banks** – sacred groves and reserves. The seed (usually vegetative) is a common property resource, collectively managed and exchanged according to local (often religious) customs and traditions.
- **Community seed exchange** – organised exchange of some stored seed from *de facto* community seed banks. They operate semi-formally and are made up of individually stored, locally multiplied, farmers and modern varieties. Some are traditional institutions, while others have been formed recently.
- **Organised seed banks –** new institutions of organised collection, storage and exchange of seed. They operate formally and are made up of individually and collectively stored, locally multiplied, modern and farmers varieties of seed.
- **Seed savers networks –** new networks organised storage and distribution of seed, mainly farmers and non-commercial varieties, between individuals and groups in a wide spread of geographical locations.

In terms of the total quantity of seed stored, traditional communal seed banks and *de facto* seed banks in particular are the most important. In the last decade or so, there has been an increase in collective seed storage projects promoted by NGOs and some plant breeding institutions that have, by and large, been set up in parallel to traditional seed banks, albeit with community participation. Many of these interventions are attempting to improve the 'weaknesses' of traditional seed banks – variable physical quality of seed and inequitable access to seed – by training farmers in plant breeding techniques, pre-harvest selection and post-harvest storage. In some projects the issues of seed exchange and distribution are being addressed, through, for example, the promotion of Community Seed Fairs or the specific targeting of beneficiary groups within the community.

From: Lewis and Mulvany, 1997

Seed fairs

Seed fairs are increasingly popular modes of promoting diversity. In Maragwa, Kenya, such an event has 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 in 1998 to 149 from 134 in 1997.

Participants gave the following reasons why they liked the seed show: farmers obtain rare crop varieties from the seed show; they identify seed sources through the show; it is a good forum for exchange of ideas on farming and exchange of seeds; farmers are exposed to national agricultural research work; the spirit of competition boosts farmer's morale and motivates farmers to diversify their crops indirectly enhancing food security; and it is a platform for interaction between farmers, students, researchers, extension staff and other development agents

Farmers also noted that to enable the seed show is to be sustained by the community and continue to be held annually, several developments are required: 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 the competition is between villages and not individual farmers per se; providing financial backup to the Location Development Committee to enable it to organise and run at least two consecutive seed shows independently; introducing other categories like food-processing, crop husbandry, livestock care and others to be competed for so as to respond to wider issues that face farmers.

From: IT-Kenya internal report.

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 perforce 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 (plant root architecture, rhizobia, soil biota, etc).

Box 5.3 Integrated Pest Management

IPM as national policy in Indonesia

In 1986, Indonesia officially adopted IPM as a national policy. By 1991, pesticide use had dropped by 70 percent, yet national rice yields increased by 10 percent during the same period. The increased productivity of rice is attributed mainly to the deployment of pest and disease resistant varieties and the encouragement of biocontrol agents. Domesday predictions that the rapid weaning from heavy dependence on commercial insecticides would lead to a collapse of rice production never came to pass. The significant of IPM to biodiversity is clear: we need to safeguard habitats as reservoirs of biocontrol agents for future deployment.

From: Srivastava et al., 1996:7

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. Besides the wider environmental and health benefits, the latter also permits the production of fish (which supplies more than 70% 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 the year 2000.

From: Ingram and Kamp, 1996

Natural resources research

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 are outlined in Box 5.4. 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).

Box 5.4 Key gaps in agricultural biodiversity research

Environment research is needed 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 is needed on the valuation of ecosystem functions and services.

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

5.2.2 More supportive social environment

For agricultural biodiversity, there are two interrelated objectives:

- recognising and facilitating the role of farmers in maintaining and managing agricultural biodiversity;
- increasing the voice and power of weaker stakeholders, 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.

Other ways of increasing the recognition given to indigenous human knowledge include providing support and capacity building to self-help groups such as seed groups and community seed banks. This could include technical support, business and group advice, and has 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. In this regard, it may be useful to remember the acronym 'GIFTS' which has been coined to express the fundamental components of Farmers' Rights: Germplasm, Information, Funds, Technologies, and farming/marketing Systems (Mooney, 1998:182).

Increasing farmers' voice

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 can also include strengthening local community organisations to allow farmers and communities to articulate their needs better (for example, for a wider choice of high quality planting material; for more appropriate technologies; for training; for research support); and to help farmers exercise a more effective 'demand pull' on national agricultural research and other support systems, thereby making the development processes truly bottom-up. The Farmer Field School approach to participatory research (see Box 5.6) 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 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 5.5).

Box 5.5 Agricultural biodiversity tourism in Peru

In Cusco, during guided tours to the communities, 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

From: FAO, 1999

5.2.4 Education, information, training, technologies, nutrition

Agricultural research

a) Participatory 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 if more conventional research methods were used.

Farmer Field Schools are a useful forum for grass-roots participatory research, which provide community-level experimental plots and technology development, as are the Community Committees for Agricultural Investigation (CIALs) used in Colombia, which have also been successful in institutionalising farmer participation in adaptive technology testing. These are described in Box 5.6.

It is important to remember that the applicability of these opportunities will depend on the differing capabilities of different farmers and farming communities.

b) Plant breeding

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 (sometimes known as *component breeding*), 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.

Where benefits arise from project level activities in, for example, farmer breeding, the question of appropriate sharing of benefits arises. The acronym GIFTS, given earlier, reminds us of the essential components of benefit-sharing in this regard.

Box 5.6 Two approaches to participatory research

Farmer Field Schools – a form of community based non-formal adult education – have been promoted by FAO through its inter-country programmes for integrated pest management (IPM) in Asia. The FFS comprises 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 in terms of 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 have used this approach in their (DFID funded) 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, 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.

From: Ashby et al., 1995 and 1996

c) Crop processing

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 and laborious and a major disincentive to growing them in large quantities.

Therefore, there is a need to support post-harvest activities, such as:

- development of small-scale processing equipment for local crops and varieties;
- development of alternative products from local crops and varieties and their by-products, to boost market opportunities.

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, such as those involved in pest-predator population dynamics, or nutrient cycling, and genetic principles of crop improvement; and then to use this education as the basis for training in specific skills such as participatory plant breeding. In many traditional farming systems, farmers know much about this already and the need is to find ways of combining this traditional knowledge with modern 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[23]. It can be difficult for farmers growing local varieties to find a market for their product, 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;

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

- enhancing community capacity in marketing skills, price negotiation, etc.

Box 5.7 DFID options at the local level

These are suggested priorities for DFID in supporting the use of agricultural biodiversity for sustainable livelihoods at the local level, summarised from the wider discussion in the above section. It is necessary to read the whole section for explanations of the detail and context of each suggested action:

- Support on-farm conservation of agricultural biodiversity using incentives appropriate to the context;
- Support farmer-to-farmer seed exchange, including seed fairs and community seed banks, where it is effective;
- Enhance local level seed production by providing technical back-stopping and business advice;
- Promote integrated crop management;
- Commit to continuing natural resources research on agricultural biodiversity;
- Strengthen local community organisations to increase farmers' voice on agricultural biodiversity issues;
- Promote income-generating projects that use agricultural biodiversity;
- Promote participatory agricultural research and plant breeding;
- Strengthen local level capacity for agricultural biodiversity management and use, including tools such as Farmer Field Schools;
- Invest in developing local markets for biodiversity-friendly agricultural products.

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 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 use of agricultural biodiversity for sustainable livelihoods. The most obvious example of this is the incentive to conversion to industrial-type agricultural systems and reduction in the use of agricultural biodiversity provided 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 always be made. These can bring to light specific opportunities for using agricultural biodiversity to reduce poverty.

We don't mean expensive taxonomic assessments, rather assessments as a decision-making tool, e.g. percentage of agro-ecosystem covered by different biodiversity by GIS, to enable identification of which parts of the agro-ecosystem are priority concerns and which are not.

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[24]. Assessments 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 research 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 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.

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

Box 5.8 Supportive agricultural extension policies in Zimbabwe
In Zimbabwe, national level encouragement of pro-agricultural biodiversity action has strengthened community capacity in some Districts. In Mudzi and Mutoko, local agricultural extension agents now actively encourage farmers to maintain on-farm crop biodiversity and farmers say this significantly influences their agricultural biodiversity decisions. District Councils have also decided to include competitions for greatest number of crops and varieties in the local agricultural shows and this has publicly validated the efforts of farmers to maintain crop biodiversity on-farm.

Source: Cromwell and van Oosterhout (1999)

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 5.9).

Box 5.9 Inappropriate seed relief in Mozambique

In Mozambique at one point during the civil war, 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 they needed to save seed 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 commodities for food relief (e.g. maize in southern Africa) to one of distributing a range of commodities, e.g. including minor but nutritious crops – such as sorghums and millets in southern Africa – this may stimulate farmers producing for the relief market to diversify production. (As such farmers tend to be in industrial-type agriculture, this could also have useful positive side-effects on levels of agricultural biodiversity in this sector.)

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 and thus 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, so new ones may need to be set up.

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).

Box 5.10 DFID options at national level

These are suggested priorities for DFID in supporting the use of agricultural biodiversity for sustainable livelihoods at the national level, summarised from the wider discussion in the above section. It is necessary to read the whole section for explanations of the detail and context of each suggested action:

- Support the mainstreaming and better coordination of national genetic resources policies and programmes, including wider stakeholder involvement in planning and implementation, and capacity building for national policy makers;
- Fund reviews of the national legal and policy framework and its impact on agricultural biodiversity. If indicated, fund work to revise seed regulatory frameworks to end legal and institutional restrictions on farmers' own activities in varietal improvement and seed exchange;
- Invest in national biodiversity assessments as a planning tool (i.e. not simply for information generation). This is consistent with national biodiversity Action Plans and with National Sustainable Development Strategies, which DFID is taking a lead role in developing and implementing;
- Support the decentralisation of agricultural research and extension services, including plant breeding;
- When required, invest in 'smart' emergency seed distribution that is tailored to specific local agro-ecological, economic and social conditions;
- Assist countries to implement intellectual property protection as required under the WTO/TRIPs agreement, in a way which is consistent with other national priorities such as the maintenance and sustainable use of agricultural biodiversity;
- Support strengthening of coordinated approaches by all relevant ministries and agencies in international negotiations, especially FAO, the CBD and WTO, which may involve capacity building for negotiators at country level.

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 be effectively carried out only at supra-national level (e.g. long-term conservation; genetic enhancement of major crop genepools; international framework for conservation, sustainable use and benefit-sharing). These various actions can be implemented through three channels, as follows:

5.4.1 The international agricultural research system

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 genebanks;
- facilitating genetic enhancement or base broadening of major crop genepools 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'[25]);
- contributing to the capacity building of national programmes, with wide stakeholder

25 New Scientist, 7 November 1998:5.

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. GEF projects should take into account the fact that the aggregate of pro-agricultural biodiversity activities at national and local levels is not necessarily positive at the global level.

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 5.11).

Box 5.11 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, resulting in the ability to charge a 5 per cent price premium. Distribution systems and educating financial institutions about the financial as well as 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:

- 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 resow 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;
- The CBD Protocol on Biosafety is currently under negotiation and should include provisions for: comprehensive risk assessment and risk management; public participation in decisions concerning genetically modified organisms (GMOs) or their products; unintentional as well as deliberate releases of GMOs or their products; and capacity building for BioSafety[26];

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26 For more detail on this, see Tapper, 1998.

- The current 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.[27]

Box 5.12 DFID options at global level

These are suggested priorities for DFID in supporting the use of agricultural biodiversity for sustainable livelihoods at the global level, summarised from the wider discussion in the above section. As such, they mainly relate to areas of EPD responsibility. It is necessary to read the whole section for explanations of the detail and context of each suggested action.

- Promote managing agricultural biodiversity for poverty reduction and development, and mainstreaming biodiversity issues, in multilateral financial institutions and other multilateral agencies (e.g. World Bank, IFAD, and regional development banks).
- Fund research into how local and global agricultural biodiversity objectives can be reconciled.
- Advocate regular re-assessments of the global agricultural research framework under the CGIAR system, to ensure its continuing responsiveness to developing countries' needs.
- Invest in development education, including raising consumer awareness of biodiversity-friendly agricultural production systems.
- Work for the successful outcome of the revision of the International Undertaking on PGRFA, and promote its eventual implementation in ways which will benefit small farmers as well as the international community.
- Ensure that the "farmers' exemption" is protected in any international agreement on patents or plant breeders rights (plant variety protection).
- Use DFID's international influence to promote the implementation of the FAO Global Plan of Action and CBD/CoP Decision 3/11, supported by appropriate financial mechanisms.

5.5 Conclusions

Taken together, the opportunities for action at local, national and global level 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, to meet the needs of the majority of the rural poor who live in areas that have fewer natural resources, are prone to natural disasters, and who are far less able to purchase inputs such as fertilisers and pesticides.

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 use of agricultural biodiversity, including approaches to plant breeding which can make use of specific adaptation. 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.

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

Bibliography

References cited in text

Altieri, M and L Merrick (1987) 'In-situ conservation of crop genetic resources through maintenance of traditional farming systems' *Economic Botany* Vol. 41 (1).

Ashby, J., T. Gracia, M. del Pilar Guerreo, C. Quiros, J. Roa, and J. Beltran (1996) 'Innovation in the organization of participatory plant breeding'. In Eyzaguirre and Iwanaga (Eds). *Participatory Plant Breeding*, Proceedings of a workshop, 26–29 July 1995, Wageningen, The Netherlands; IPGRI.

Ashby, J., T. Garcia, M. Guerrero, C. Quiros, J. Roa and J. Beltran (1995) 'Institutionalising farmers participation in adaptive technology testing with the "CIAL"'. *ODI Agricultural Research & Extension Network Paper* No. 57. London: Overseas Development Institute.

Barbier, E., J. Burgess and C. Folke (1994) *Paradise Lost? The Ecological Economics of Biodiversity*. London: Earthscan.

Bellon, M. (1996) 'The dynamics of crop intraspecific diversity: a conceptual framework at the farmer level'. *Economic Botany* Vol.50.

Brush, S., M. Bellon and E. Schmidt (1988) 'Agricultural development and maize diversity in Mexico'. *Human Ecology* Vol. 16.

Carney, D. (1998) 'Implementing the Sustainable Rural Livelihood Approach' in Carney, D. (ed). (1998) *Sustainable Rural Livelihoods: What contribution can we make?* Papers presented at the Department for International Development's Natural Resources Advisers' Conference, July 1998. London: Department for International Development.

CGIAR (1997) *Bioengineering of Crops* Washington: Consultative Group on International Agricultural Research.

Collins, W. and M. Petit (1998) 'Strategic Issues for National Policy Decisions in Managing Genetic Resources.' Environmentally Sustainable Development Agricultural Research and Extension Group *Special Report* No. 4. Washington DC: World Bank.

Conway, G. (1997) *The Doubly Green Revolution: Food for all in the Twenty-First Century*. London: Penguin Books.

Cromwell, E. and S. van Oosterhout (1999) 'On-farm conservation of crop diversity: policy and institutional lessons from Zimbabwe' in Brush, S. (ed). *Genes in the Field: Conserving Crop Diversity On-Farm* CRC Press, New York, and IDRC, Ottawa.

Dahlberg, K. (1979) *Beyond the Green Revolution: the Ecology and Politics of Global Agriculture*. New York: Plenum Press.

FAO (1999) *Sustaining Agricultural Biodiversity and Agro-Ecosystem Functions.* Rome: Food and Agriculture Organisation of the United Nations. (http://www.fao.org/WAICENT/FAOINFO/SUSTDEV/EPdirect/EPre0063.htm).

FAO (1998) *The State of the World's Plant Genetic Resources for Food and Agriculture* Rome: Food and Agriculture Organisation of the United Nations.

Gomez-Pompa, A. and A. Kaus (1992) ‘Taming the wilderness myth’ *Bioscience* 42: 271–279.

Grimble, R. and M. Laidlaw (1998) *Biodiversity conservation in rural development: lessons for better addressing biodiversity concerns in planning rural and agricultural development projects*. Report prepared by the Natural Resources Institute for the Environment Department of the World Bank (mimeo).

Ingram, D. and K. Kamp (1996) ‘Bangladesh: building on IPM – INTERFISH and NOPEST programmes’. Case study in Thrupp, LA (Editor*) New Partnerships for Sustainable Agriculture*, World Resources Institute, Washington.

ITDG (1996) ‘Farmers safeguarding agricultural diversity through their crop husbandry.’ Booklet in *Dynamic Diversity* series. Rugby: Intermediate Technology Development Group.

Jarvis, D. and T. Hodgkin (1997) ‘Farmer decision making and genetic diversity’ in Brush, S. (ed). (1998) *Genes in the Field: Conserving Crop Diversity On-Farm* CRC Press, New York, and IDRC, Ottawa.

Jarvis, D. and T. Hodgkin (1996) *Wild relatives and crop cultivars.* Paper presented at the international symposium on in-situ conservation of plant genetic diversity, Antalya, Turkey, November 1996.

Lenné, J. (1999) *Conservation of agrobiodiversity and global food security*. London: University of Greenwich.

Leskien, D. and M. Flitner (1997) ‘Intellectual Property Rights and Plant Genetic Resources: Options for a *Sui Generis* System’ *Issues in Genetic Resources* No. 6 Rome: International Plant Genetic Resources Institute.

Lewis, V. and P. Mulvany (1997) *A typology of community seed banks*. Chatham: Natural Resources Institute.

Louette, D. and M. Smale (1996) ‘Genetic diversity and maize seed management in a traditional Mexican community: implications for in-situ conservation of maize’ CIMMYT *Natural Resources Group Paper* No. 96-03.

Mooney, P. (1998) ‘The parts of life: agricultural biodiversity, indigenous knowledge and the role of the Third System’ *Development Dialogue*.

Mulvany, P. (1998) *TRIPs, Biodiversity and Commonwealth Countries: Capacity building priorities for the 1999 review of TRIPs Article 27.3(b)* Paper prepared for the Commonwealth Secretariat and Quaker Peace & Service by Intermediate Technology Development Group.

ODI Seeds & Biodiversity Programme (1996) ‘Seed Provision During and After Emergencies’ ODI Relief and Rehabilitation Network *Good Practice Review* No.4. London: Overseas Development Institute.

Posey, D. A. (1995) *Indigenous peoples and traditional resource rights: a basis for equitable relationship?* Green College, Oxford University.

Prescott-Allen, R. (1998) *Manual on Assessment of Biodiversity – with particular reference to the CBD* (mimeo, draft). International Union for the Conservation of Nature.

Primack, R. (1993) *Essentials of conservation biology*. Sinauer.

Settle W. H., H. Ariawan; E. Tri Astuti, W. Cahyana, A. L. Hamkin, D .Hindayana, A. S. Lesterei, Pajarningsih and Sranto (1996) 'Managing Tropical Rice Pests through Conservation of Generalist Natural Enemies and Alternative Prey.' *Ecology* 77:7 1975–1988.

Shantharam, S. (1997) 'Need to move biotechnologies forward mobilises scientific community to address global safety concerns' *Diversity* Vol.13, No.2&3.

Simmonds, N. (1962) 'Variability in crop plants, its use and conservation'. *Biological Review* Vol. 37.

Simmonds, N. (1993) 'Introgression and incorporation: strategies for the use of crop genetic resources' *Biological Review* Vol. 68.

Srinivasan, N. (1997) 'The significance of microbial biodiversity to biotechnology' Paper presented at Satellite Symposium on 'Biotechnology and Biodiversity: Scientific and Ethical Issues', at 2nd International Crop Science Congress New Delhi, India, 15–16 November 1996.

Srivastava, J., N. Smith and D. Forno (1996) 'Biodiversity and agriculture: implications for conservation and development.' *World Bank Technical Paper* No. 321. Washington DC: World Bank.

Swanson, T., D. Pearce and R. Cervigni (1993) 'The appropriation of the benefits of plant genetic resources for agriculture: an economic analysis of the alternative mechanisms for biodiversity conservation' *Background Study Paper* No.1 for First Extraordinary Session of the FAO Commission on Plant Genetic Resources. Rome: UN Food and Agriculture Organisation.

Tapper, R. (1998) 'Food production, choice and security: the role of the Biosafety Protocol and the implications of genetic engineering' Paper prepared for the UK Food Group, September 1998 (available on http://dspace.dial.pipex.com/ukfg/ukabc.htm).

Thrupp, L. (1998) *Cultivating Diversity: Agro-biodiversity and Food Security*. Washington, D. C.: World Resources Institute.

Tripp, R. (1999) The debate on genetically modified organisms: relevance for the South. ODI *Briefing Paper* 1999 (1). London: Overseas Development Institute.

Tripp, R. and N. Louwaars (1997) 'Seed regulation: choices on the road to reform' *Food Policy* Vol. 22.

UNEP (1993) *Guidelines for country studies on Biological Diversity*. Nairobi: UN Environment Programme.

Wilkes, H. (1977) 'Hybridisation of maize and teosinte in Mexico and Guatemala and the improvement of maize' *Economic Botany* Vol. 31.

Wilson, O. (ed.) (1988) *Biodiversity* Washington, D. C.: National Academy Press.

Wood, D. (1998) 'Ecological principles in agriculture' *Food Policy* Vol. 23 (4).

Wood, D. and J. Lenné (1993) 'Dynamic management of domesticated biodiversity by farming communities' Paper presented at Norway/UNEP expert conference on biodiversity.

Web sources

UK Agricultural Biodiversity Coalition (UKabc) Home Page:
http://dspace.dial.pipex.com/ukfg/ukabc.htm

Convention on Biological Diversity (CBD):
http://www.biodiv.org/cop4/cop4docs.html

Food and Agriculture Organisation of the United Nations (FAO):
http://www.fao.org/AG/cgrfa/8html/cgrfa8-infl2.htm

Other useful publications

Cooper, D., R. Vellve and H. Hobbelink (1992) *Growing Diversity: genetic resources and local food security*. London: Intermediate Technology Publications.

Cromwell, E. and van Oosterhout, S. (eds.) (forthcoming) *Supporting Diversity Through Sustainable Livelihoods: What are farmers' choices?* Proceedings of a workshop held in Harare, Zimbabwe, 5-7 November 1996.

De Boef, W., K. Amanor and K. Wellard with A. Bebbington (1993) *Cultivating Knowledge: genetic diversity, farmer experimentation and crop research.* London: Intermediate Technology Publications.

Eyzaguirre, P. and M. Iwanaga (eds). (1996) *Participatory Plant Breeding*. Proceedings of a workshop on participatory plant breeding held in Wageningen, The Netherlands, 26–29 July 1995.

Jarvis, D. and T. Hodgkin (editors) (1998) *Strengthening the scientific basis of in-situ conservation of agricultural biodiversity on-farm. Options for data collecting and analysis*. Proceedings of a workshop to develop tools and procedures for in-situ conservation on-farm held in Rome, Italy, 25–29 August 1997. Rome: International Plant Genetic Resources Institute.

Joshi, A. and J. Witcombe (1996) 'Farmer participatory crop improvement. II. Participatory varietal Selection, a case study in India' *Experimental Agriculture* Vol. 32.

Kenmore, P., E. Southwick and L. Southwick (1992) 'Estimating the economic value of honey bees as agricultural pollinators in the US'. *J Econ Entomol* 85(3) 621–633.

Maxted, N., B. Ford-Lloyd and Hawkes, J. (eds.) (1997) *Plant Genetic Conservation: the in-situ approach* London: Chapman and Hall.

Mulvany, P., S. Bunning and Minten, V. (eds.) (1997) *Farming systems approaches for the sustainable use and conservation of agricultural biodiversity and agro-ecosystems* Report on a Technical Workshop, 19–20 June 1997, FAO, Rome. Rome: UN Food and Agriculture Organisation.

Sperling, L. and M. Loevinsohn (eds). (1996) *Using Diversity: enhancing and maintaining genetic resources on-farm* Proceedings of a workshop held at New Delhi, India, 19–21 June 1995.

Sthapit, B., K. Joshi and J. Witcombe (1996) 'Farmer participatory crop improvement. III.

Participatory plant breeding, a case study for rice in Nepal' *Experimental Agriculture* Vol.32.

Tripp, R. (1996) 'Biodiversity and modern crop varieties: sharpening the debate.' *Agriculture and Human Values* Vol.13.

van der Heide, W. and R. Tripp with W. De Boef (1996) *Local Crop Development: an annotated bibliography* Rome: International Plant Genetic Resources Institute/Wageningen: CPRO-DLO (CGN)/London: Overseas Development Institute.

Witcombe, J. (1999) 'Do farmer participatory methods apply more to high potential areas than to marginal ones?' *Outlook on Agriculture*, March 1999.

Witcombe, J., A. Joshi, K. Joshi and B. Sthapit (1996) 'Farmer participatory crop improvement. I. Varietal Selection and breeding methods and their impact on biodiversity' *Experimental Agriculture* Vol.32.

Zimmerer, K. (1992) 'Land use modification and labour shortage: Impacts on the loss of native crop diversity in the Andean highlands.' In Jodhai, N., M. Banskota and T. Partap *Sustainable Mountain Agriculture*. New Delhi: Oxford and IBH Publishing Co.

Appendix 1 Global agreements affecting agricultural biodiversity

The key international agreements relating to the conservation, sustainable use and benefit-sharing of agricultural biodiversity are summarised in Table A1.1.

Table A1.1 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 171 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. 1996	Agricultural biodiversity
CBD Protocol on Biosafety	Under negotiation	International Movement 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)	To take place in 1999	As above
UPOV Convention	1991 agreement now in force	A *sui generis* system for intellectual property protection of plant varieties

Appendix 2 Convention on Biological Diversity

The Convention on Biological Diversity (CBD) was signed at the 1992 UN Conference on the Environment and Development and has subsequently been ratified by 171 countries. Two Decisions by the CBD's Conference of the Parties (III/11 and IV/6) concern the conservation and sustainable utilisation of agricultural biodiversity and provide an excellent summary of the need for, and the basis of, required practical and policy actions, some of which are summarised below (See Appendix Table A2.1).

Other decisions on different ecosystems and cross-cutting issues including biosafety (a Protocol is currently under negotiation), access and benefit sharing, ecosystem approaches and so on, are also of relevance.

Decision III/11 agreed at the Third Conference of the Parties, November 1996 recognises that although there is much evidence of the loss of agricultural biodiversity and the continuing threats to its development and use, there is very limited understanding of the measures that are needed to develop work that will address these problems. For this reason the COP decided to develop a phased multi-year programme of activities on agricultural biodiversity aiming to promote:

- the positive effects and mitigate the negative impacts of agricultural practices on biodiversity in agro-ecosystems and their interface with other ecosystems;
- the conservation and sustainable use of genetic resources of actual or potential value for food and agriculture; and
- the fair and equitable sharing of benefits arising out of the utilisation of genetic resources for food and agriculture.

It addresses (i) genetic and species diversity, and (ii) the wider issue of ecosystems and habitats as follows: the ecosystem approach; the integrated, multi-disciplinary land-use approach (resources planning, development and management); and the holistic systems approach to address the multiple objectives of SARD (land-use pressures and resource degradation, management of animal, plant and microbial diversity, and management of land and water resources, air and climatic factors, and wildlife habitats).

Parties are encouraged to:

- Promote the transformation of unsustainable agricultural practices into sustainable production practices adapted to local biotic and abiotic conditions, in conformity with the ecosystem or integrated land-use approach;
- Promote the use of farming practices that not only increase productivity, but also arrest degradation as well as reclaim, rehabilitate, restore and enhance biological diversity;
- Promote the mobilisation of farming communities including indigenous and local communities for the development, maintenance and use of their knowledge and practices in the conservation and sustainable use of biological diversity in the agricultural sector with specific reference to gender roles.

In their national strategies, programmes and plans, Parties are encouraged to address 14 action areas which can be grouped into three categories:

i identification, monitoring and assessment actions;

ii actions to promote the conservation and sustainable use of agricultural biodiversity;

iii actions addressing economic and legal aspects.

Parties are further encouraged to develop national strategies, programmes and plans that focus on certain aspects of plant, animal and microbial genetic resources, notably:

- The key elements of the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture;
- The development of inventories which consider the status of Farm Animal Genetic Resources and measures for their conservation and sustainable utilisation;
- Microbial Genetic Resources (e.g. micro-organisms of interest for agriculture including mycorrhizal fungi; symbiotic soil micro-organisms e.g. nitrogen fixing).

Attention is also drawn to natural resources management and the need for an integrated and multi-disciplinary approach to the planning, development and management of land resources, and to ensure a holistic systems approach, which goes beyond an agricultural focus, to address the multiple objectives related to sustainable agriculture and rural development. It was generally agreed that a focus on agricultural biodiversity will require addressing the wider issue of degradation of biological resources and the need for improving the management of biodiversity and other natural resources.

While the issue of agricultural biodiversity is being addressed as a distinct thematic area, it is also cross-cutting in the sense that it is important to all habitable ecosystems. Decision III/11 addresses genetic resources important to food and agriculture in marine and coastal, forest, inland waters, Mediterranean and mountain ecosystems, as well as in drylands, grassland and savannahs, for which work programmes have been or will be established in the framework of the CBD as well.

Decision IV/6 agreed at the Fourth Conference of the Parties, 1998, re-emphasised the need for speedy implementation of Decision III/11 and, inter alia, decided:

- That Governments, funding agencies, the private sector and non-governmental organisations should join efforts to identify and promote sustainable agricultural practices, integrated landscape management of mosaics of agriculture and natural areas, as well as appropriate farming systems that will reduce possible negative impacts of agricultural practices on biological diversity and enhance the ecological functions provided by biological diversity to agriculture;
- To expand the focus placed on soil micro-organisms in decision III/11 to address all soil biota (as well as pollinators);
- To request the Executive Secretary to report to the Conference of the Parties on the impact of trade liberalisation on the conservation and sustainable use of agricultural biological diversity in consultation with relevant bodies, such as the World Trade Organisation;
- To request SBSTTA to consider and assess whether there are any consequences for the conservation and sustainable use of biological diversity from the development and use of new technology for the control of plant gene expression, such as that described in United States patent 5723765 (the so-called ‘terminator gene’ that makes seeds sterile), and to elaborate scientifically based advice to the Conference of the Parties.

In January 2000, in preparation for the 5th Conference of the Parties to the CBD in May 2000, SBSTTA will consider the results of the assessment of ongoing activities and instruments on agricultural biodiversity, and the identification of priority issues and areas of attention. The outcome of this will be a programme of work, agreed by the COP, to be implemented by all Parties, supported by key organisations, notably FAO, the Global Environment Facility (GEF) and the CGIAR/World Bank.

Appendix Table 2.1: CBD Decision III/11 – Summary of Key Points

Decision III/11 addresses: 1. Genetic and species diversity, and 2. Wider issue of ecosystems and habitats: • Ecosystem approach • Integrated, multi-disciplinary land use approach (resources planning- development – management) • Holistic systems approach to address multiple objectives of SARD - land use pressures and resource degradation - management of animal + plant + microbial diversity - management of land and water resources, air and climatic factors, and wildlife habitats Through the following processes: **A. Agricultural biodiversity assessment** • of ongoing activities and existing instruments of international and national levels • of inputs by international and regional organisations coordinated by FAO • of inputs by Governments coordinated by CBD Secretariat • through case studies (exchange through CHM) • bearing in mind the indicative list of thematic areas **B. Actions by parties at national level** To promote : • transformation of unsustainable agricultural practices into sustainable practices • use of farming practices that increase productivity, arrest degradation and rehabilitate or restore biological diversity • mobilisation of indigenous and local farming communities and their knowledge and practices, with specific reference to gender To develop national strategies, programmes and plans, focusing on the diversity of genetic resources of: • plant, • farm animals and • micro-organisms Covering 14 action areas: • identification, monitoring and assessment actions • actions to promote conservation and sustainable use of agricultural biodiversity • actions that address economic and legal issues **C. Encouraging work and contributions of key organisations** • Technical and policy support of FAO - revision of the International Undertaking on PGR - strengthening of the Global System - implementation of Global Plan of Action for the conservation and sustainable use of PGRFA - further development of the Global Strategy for management of farm animal genetic resources • Financial support of GEF and donors • Assistance of WTO and CTE to develop a better appreciation of the relationship between trade and agricultural biodiversity • Assistance of the Clearing House Mechanism to promote and facilitate development and transfer of technology (and exchange of relevant information).

Appendix 3 Global plan of action for the conservation and sustainable use of plant genetic resources for food and agriculture

The Global Plan of Action for the conservation and sustainable use of plant genetic resources for food and agriculture was adopted by 150 countries at the FAO International Technical Conference on Plant Genetic Resources, Leipzig, Germany, in June 1996. The International Technical Conference also adopted the 'Leipzig Declaration' through which governments committed themselves to implement the Global Plan of Action. The Plan was endorsed by the Conference of the Parties of the Convention on Biological Diversity at their third meeting in Buenos Aires, and by world leaders at the World Food Summit convened by FAO, in November 1996.

The Leipzig Declaration asserts that 'our primary objective must be to enhance world food security through conserving and sustainably using plant genetic resources'.

The Global Plan of Action is intended as a framework, guide and catalyst for action at community, national, regional and international levels. It seeks to create an efficient system for the conservation and sustainable use of plant genetic resources for food and agriculture, through better cooperation, coordination and planning and through the strengthening of capacities and enhanced awareness. It is an essential contribution to the successful implementation of the Convention on Biological Diversity.

The Plan consists of 20 priority activities organised into four main areas: in-situ conservation and development; ex-situ conservation; use of PGRFA, and institutions and capacity building (Appendix Table A3.1). Of particular relevance to this paper is the emphasis placed on:

- promoting sustainable agriculture through diversification of crop production and broader diversity in crops (Activity 11), as well as;
- promoting development and commercialisation of a wider range of varieties and species (Activity 12); and,
- supporting this through the development of new markets for "diversity rich" products (Activity 14) helped by;
- promoting public awareness of the value of PGRFA conservation and use (Activity 20);
- These activities could be considered the 'motor' or incentive for achieving many of the conservation and capacity building goals.

Four further key features of the Global Plan of Action are also highlighted.

First, the Plan aims to strengthen the links between conservation and utilisation, through better information generation and management (Activities 1, 9, 17, 18), by improving the links between conservers and breeders through national programmes and crop networks, and by investing in pre-breeding activities (Activity 10). Similarly, the Plan aims to promote not only the greater but sustainable use of diversity, but also the strategic deployment of genetic resources and practices which may lead to the maintenance of greater diversity in use. It also promotes an integrated approach to conservation, using both in-situ and ex-situ approaches and strengthening the links and complementarities between them.

Secondly, it focuses on action at the national level. Particular attention is given to strengthening national programmes, and especially the necessary co-ordination mechanisms, training and capacity building – all regarded as pre-requisites to effective action. Whilst two activities of the Plan focus on these areas (Activities 15 and 19), action at the national level is stressed in many other activities. The importance of international collaboration is also recognised. The Plan gives particular importance to regional and sub-regional networks (Activity 16).

Thirdly, the Plan promotes the full participation of farmers and local communities. The activity on national programmes (Activity 15) emphasises the need to involve all stakeholders including farmers and local communities, with particular attention to women farmers. An entire priority activity is devoted to on-farm conservation and improvement of PGRFA (Activity 2). And perhaps more significantly, the importance of farmer participation is integral to several other activities. Thus the importance of local knowledge (Activity 1) and of involving local communities in collecting (Activity 7), in-situ conservation (Activity 4), evaluation (Activity 9), participatory plant breeding (Activity 11), management and development of under-utilised species (Activity 12), and seed distribution (Activity 13) is recognised. The training needs of farmers and local communities is addressed (Activity 19). Also, the Global Plan of Action contains a special programme to support traditional farming systems in cases of war and natural disasters (Activity 3).

Fourthly, the Plan promotes complementarily between the public and private sectors, based on recognition of the strengths of each. The Plan, by its very nature, focuses on activities, which need to be supported by public funds, especially at an international level. These activities include long-term conservation itself (Activities 2, 4 and 5–8), as well as other upstream, pre-competitive activities such as germplasm evaluation and pre-breading, especially long-term programmes to broaden the base of breeders' populations. Besides these ‘public goods’, public support is also required to meet the needs of resource poor farmers for improved varieties and seeds, since they are often unable to express an effective market demand (Activities 2, 11–14).

Appendix Table A3.1 List of priority activities identified in the Global Plan of Action

In-situ conservation and development

1. Surveying and inventorying plant genetic resources for food and agriculture
2. Supporting on-farm management and improvement of PGRFA
3. Assisting farmers in disaster situations to restore agricultural systems
4. Promoting *in-situ* conservation of wild crop relatives and wild plants for food production

Ex-situ conservation

5. Sustaining existing *ex-situ* collections
6. Regenerating threatened *ex-situ* accessions
7. Supporting planned and targeted collecting of plant genetic resources for food and agriculture
8. Expanding *ex-situ* conservation activities

Utilisation of plant genetic resources

9. Expanding the characterisation, evaluation and number of core collections to facilitate use
10. Increasing genetic enhancement and base-broadening efforts
11. Promoting sustainable agriculture through diversification of crop production and broader diversity
12. Promoting development and commercialisation of under-utilised crops and species
13. Supporting seed production and distribution
14. Developing new markets for local varieties and “diversity-rich” products

Institutions and capacity building

15. Building strong national programmes
16. Promoting networks for plant genetic resources for food and agriculture
17. Constructing comprehensive information systems for PGRFA
18. Developing monitoring and early warning systems for loss of PGRFA
19. Expanding and improving education and training
20. Promoting public awareness of the value of PGRFA conservation and use

Appendix 4 The valuation of crop diversity[28]

Crop diversity is the component of agricultural biodiversity on which most valuation work has been done. Crop diversity consists of genetic resources and knowledge. In economic terms, these constitute two complementary inputs (each one is necessary, but useless without the other) in the production of useful goods – in this case, new crop varieties. However, over time knowledge, and the technologies developed on the basis of that knowledge, may substitute for a specific genetic resource.

The value of these inputs is derived from the value of the final product – i.e. the new crop variety – which in turn depends on the productivity of the new variety. If the two inputs are strictly complementary, their joint value can be easily derived from the value of the final product, although the value of each one cannot be separately assessed (strictly speaking, each one is valueless without the other).

The price paid for each input – the crop genetic resources and the knowledge that goes with them – depends on the markets from which they are obtained:

- if one is a public good, i.e. freely accessible, it will have no price and the total joint value will be captured by the other one;
- if one input is obtained form a competitive market, its price is determined by that market and the other one will receive the residual value (in economic terms, a 'rent');
- if both inputs are acquired on competitive markets, their prices are set on those markets and the volume of production of the new crop variety will adjust to such a level that the value of the last unit of product produced equals the cost of the last unit of inputs used (this is determined by the physical productivity of the two inputs, and their prices);
- if there is no market for either input and each one is owned by different stakeholders, the relative returns have to be bargained between the stakeholders.

For crop diversity, there are further complications as the final product is the result of adding new knowledge step-by-step and generating intermediate products in an iterative process. Thus the key issue becomes assessing the relative value of the several knowledge components incorporated in the final product (in the absence of IPRs, these knowledge components are all complementary inputs of the genetic resources involved, i.e. they have no market value without being combined with the genetic resources).

Market failure can arise because market mechanisms do not recognise the value to society of conserving crop diversity for some as yet unknown future use (the precautionary principle), or because the private sector usually neglects public goods such as agricultural biodiversity conservation. This market failure could conceivably be corrected by a government intervention such as the subsidisation of in-situ conservation until the marginal value of agricultural biodiversity conserved equals the marginal cost of the subsidy (although this involves understanding complex genetic phenomena and being able to value a specific gene pool). There is also a role for ex-situ conservation, depending on technical factors – and its costs, about which there are few hard data.

This production economics approach to valuing crop diversity has some relevance for valuing individual genepools that can be used as inputs in the production of new crop varieties, although it offers little about how to deal with market failure. More importantly, it cannot deal with the common property functions of agricultural biodiversity (particularly, ecosystem functions and services, which are conventionally undervalued in financial and economic analyses of agricultural

28 The following explanation is taken from Collins and Petit, 1998:15–18 with some adaptations which are the present author's responsibility.

biodiversity), nor with positive and negative externalities, nor with recreational, health, cultural, educational, scientific and aesthetic ecological functions.

Agricultural biodiversity is essential so that organisms and ecosystems can adapt to evolutionary pressures, i.e. it provides *adaptability*. But the very process of *adaptation*, whether by natural selection, or human selection (by farmers or formal sector breeders) reduces agricultural biodiversity by focusing on desired characters and discarding others. Therefore there is uncertainty concerning how much we should adapt agricultural biodiversity to our present needs, and how much we should preserve it to ensure the adaptability of our agricultural systems in the future.