Managing Agricultural Resources for Biodiversity Conservation:

A Guide to Best Practices

compiled by:
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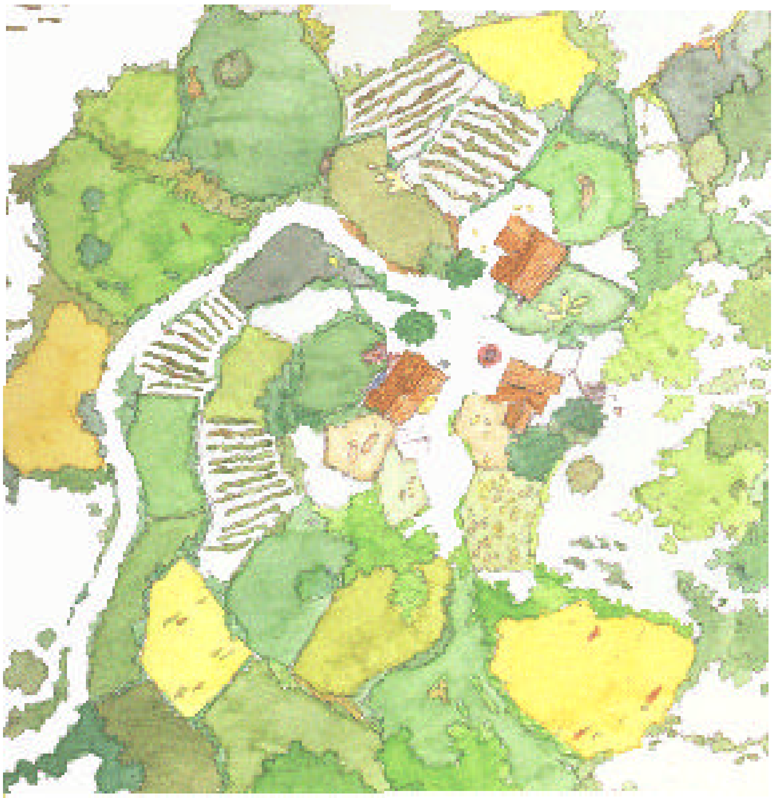

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Introduction

The Biodiversity Planning Support Programme (BPSP) of the Global Environment Facility (GEF), implemented by the United Nations Development Programme (UNDP) and United Nations Environment Programme (UNEP), has a mandate to provide assistance to national biodiversity planners as they develop and implement their national biodiversity strategy and action plans (NBSAPs) or equivalent plans, programmes, and policies. As part of the overall Programme, UNEP holds responsibility for identifying best practices, guidelines, and other tools to enhance the biodiversity planning process. In particular, these guidelines are being developed for areas that have been identified by biodiversity planning practitioners as "poorly defined emerging issues".

Agrobiodiversity was not originally considered to be part of the biodiversity that was going to be conserved by the global initiative that became the Convention on Biological Diversity. But once the Convention was forged, and appropriate targets for the programme of work were discussed, there was a strong outcry, particularly from developing countries, to incorporate agricultural concerns into the work of the Convention. Not only do agricultural systems impact heavily on the conservation of wild biodiversity, but it has been shown in multiple ways that farming landscapes host a large share of the planet's biodiversity, and much that is extremely critical to human livelihoods.

In 1996, the Third Conference of Parties of the Convention on Biological Diversity established a programme of work on Agricultural Biological Diversity (Decision III/11). Agricultural biodiversity was defined to include all components of biological diversity of relevance to food and agriculture. This includes: genetic resources of harvested crop varieties, livestock breeds, fish species and non-domesticated ("wild") resources within field, forest, rangeland and aquatic ecosystems; biological diversity that provides ecological services such as nutrient cycling, pest and disease regulation, maintenance of local wildlife, watershed protection, erosion control, climate regulation, and carbon sequestration. This range of topics was then further elaborated at the Fifth Conference of Parties in Nairobi in the year 2000, with Decision V/5. This means, at a minimum, that the topic will need to be addressed in national reports and in National Biodiversity Strategies and Action Plans.

Unfortunately, for all its recent attention, agrobiodiversity still falls under the category of being a "poorly defined emerging issue". In general, countries have taken agrobiodiversity to refer primarily to crop genetic resources, as this is where most of the conservation efforts have been focused. Even here, interventions to assure conservation are not evident or simple; as has been noted (Thies 2000), many other aspects of biodiversity such as forests or wildlife are threatened by overuse, yet agrobiodiversity and traditional knowledge of farm genetic resources is threatened because it risks to fall into disuse, to be supplanted by modern technologies. How to increase that use while assuring the custodians of agrobiodiversity receive appropriate benefits remains a thorny problem. At the same time, other aspects of agrobiodiversity – such as soil biodiversity, and wild biodiversity in farming landscapes– are even much poorer documented and understood. Many aspects relate to the extremely numerous but taxonomically least studied aspects of flora and fauna: soil microorganisms, insect pests and natural enemies, and pollinators. As national biodiversity planners are asked to incorporate agrobiodiversity into their work and plans, we must recognize that there is no definitive, authoritative guide to agrobiodiversity in all its manifestations, and little experience with how it interacts with policy decisions.

That said, agrobiodiversity conservation has the potential to be one of the leading lights of the Convention on Biological Diversity. With many other areas of biodiversity conservation, conflicts over resource use abound, and it seems difficult even for environmental economists to show us, convincingly, that conservation can mean economic benefits, at least in the short run. In agricultural systems, however, there is ample room for “win-win” solutions: for example, less use of pesticides which decrease biodiversity, in exchange for low-input sustainable agriculture with reduced input costs for farmers. Or, conservation of pollinators in hedgerows, leading to increased crop yields. Or, systematic and sustainable exploitation of wild biodiversity, in farm settings such as game ranches.

In the words of one of our expert reviewers (Knowledge Systems); “There is a danger in Biodiversity Planning to focus on the measures needed to protect biodiversity and ensure sustainable use and benefit sharing. In work on agricultural biodiversity, it is not so much its ‘protection’ as its ‘development’ through diverse management practices, that becomes key. Indeed, it can be said that agricultural biodiversity is the product of a healthy sustainable agroecological production system, as well as being its base component. So we are dealing with a highly dynamic system in which people are at the centre.”

With this in mind, we have undertaken the drafting of this guide to existing best practices in managing agricultural resources for biodiversity conservation, based on the best available information in late 2001. The guide adopts a structure for looking at agrobiodiversity that has emerged from expert meetings and the CBD’s liaison group on agrobiodiversity: of farm genetic resources, ecosystem services, knowledge systems, and landscape level issues. The case studies touch on measures and experiences to conserve these aspects of agrobiodiversity in Brazil, Mexico, Cuba, Russia, the Commonwealth of Independent States region, Yunnan province in China, Ghana, Nigeria, Kenya, Ethiopia, Zimbabwe, South Africa, India, the Philippines and Vietnam. Case studies were reviewed and additional information provided by scientific experts in the fields of pollination biology, soil biodiversity, biodiversity that migitates pests and diseases, crop genetic resources, animal genetic resources, traditional knowledge, wild biodiversity in agricultural landscapes, and landscape level considerations of agricultural biodiversity.

Case study authors, expert reviewers and other resource persons were brought together in a workshop held in Nairobi in July 2001, to identify a set of principles, practices and tools of mutual benefit to sustainable agriculture and to biodiversity conservation planning. This guide has been developed on the basis of the key priniciples and practices identified at the workshop, which have then been linked to existing tools and references to help National Biodiversity Strategy and Action Planners to incorporate these concepts in their plans and initiatives.

Structure of the Guide

This guide has been structured in three parts. First, we look at principles relevant to the conservation of agricultural genetic resources, which are largely managed on-farm (with the exception of wild relatives of crops). Moving out further from a farm field focus, we consider principles relevant to the conservation of ecological services, which generally require some wild habitat in farm landscapes. And finally, we examine the conservation of wild biodiversity in agricultural areas, and the need to "biodiversify" agricultural landscapes.

Reporting Conventions

We have followed a standard format throughout this guide. First, for each part, a list of principles is given. Each principle is then addressed. Principles are noted in green type-face as:

Principle 1.1 Baseline Information needs to be strengthened.

Following this, best practices are noted as:

BEST PRACTICES

Cataloguing, characterising and databasing genetic resources

Where possible, models of actual experiences in different countries are noted as below:

India: Farmer's names for their varieties of rice in selected villages of Madhya Pradesh were shown to adequately reflect the patterns of variation found by PCA, a modern genetic analysis. PCA analysis revealed that farmer-named varieties corresponded to over 65% of the true genetic variation. The landraces showed a continuum of variation, rather than distinct clusters (Motiramani et al 2000).

and lastly, relevant tools, with an emphasis on those available at no cost, over the internet, are noted as:

Tools

- IPGRI has a number of resources available in plant genetic resources for agricultural and biodiversity planners in this regard: http://www.ipgri.org.

1. Principles for Conserving Farm Genetic Resources

More often than not, agricultural genetic resources have been the primary, if not sole feature in national biodiversity strategy discussions on agrobiodiversity. There is a compelling reason for this focus: the future food supply of the world depends on the exploitation of genetic diversity for crop and animal improvement (Reid and Miller 1989, World Conservation Monitoring Centre 1992, Gollin and Smale 1999). At the same time, many of the world's farmers depend directly on the harvests of genetic diversity they sow for food, fodder and other economic, cultural and ecological activities (Brush 1991, Bellon 1996, Zimmerer and Douches 1991, Mellas 2000, Jarvis 1999). The use of locally adapted crop varieties may also serve to improve ecosystem health by their reduced needs for pesticides and fertilisers and their effect on improving soil structure (Zhu et al. 2000, Gliessman 1998, Glass and Thurston 1978, Vandermeer 1995, Pimental et al. 1997). Moreover, the availability of locally adapated crop varieties to particular microniches may be one of the few resources available to resource-poor farmers to maintain or increase production on his or her field (Jarvis et al. 2000).

From this brief discussion, sweeping from world food security to resource-poor farmers, it is apparent that farm genetic resouces have value both at a global level- in terms of agricultural genetic diversity and ecoystem health- and at a highly localised level, in benefiting poor farming communities.

Since the early 1980s, plant genetic resources in particular have become a hotly debated political issue. Within this global limelight, much has changed in the principle and concept of ownership of plant genetic resources. The resources once considered the "global commons", which may have benefited a smaller audience than this- is now of much common concern, and recognised national rights. Yet each government still has a long way to go in applying those rights in ways that provide maximum benefits to themselves, and to the global community.

One major omission from many discussions of farm genetic resources is the diversity of domesticated livestock. At present, there is a frustratingly small awareneness that the genetic resources of animals are a global asset of inestimable value to humankind, for use in both traditional farming systems and modern agriculture. Along with little awareness, there is little investment in livestock genetic diversity conservation. Yet livestock resources account for 35 to 40% of total agricultural production worldwide. Of the 5,000 known breeds of land races of domesticated and semi-domesticated animals used for food and agricultural production, over 30% have been lost in modern times, and about 30% of those remaining are considered at risk (Rege, pers. comm.). ***Ex-situ*** conservation of animal genetic resources is highly problematic. As genetic diversity erodes, our capacity to maintain and enhance livestock productivity and sustainable agriculture decreases, along with the ability to respond to changing conditions. Farm animal genetic resources must be considered equally along with plant genetic resources, in this component of agrobiodiversity conservation.

Key principles for the conservation of farm genetic resources are:

1.1 Baseline information needs to be strengthened.

1.2 It is important to identify ecosystem management practices and associated techniques and policies to promote positive and mitigate negative impacts on farm genetic resources.

1.3 Need to develop linkages between agricultural genetic conservation and use and benefit sharing, as agricultural genetic biodiversity resources are essential to global agricultural productivity.

1.4 Strengthening community management of agricultural resources increases plants and animal diversity essential for secure livelihoods.

1.5 Develop appropriate partnerships.

1.6 The private sector should take responsibility for ensuring that their activities support the conservation of agricultural genetic resources.

1.7 Issues of access, benefit sharing and intellectual property rights are central to the NBSAP process so planners need to carefully consider the position of various stakeholders.

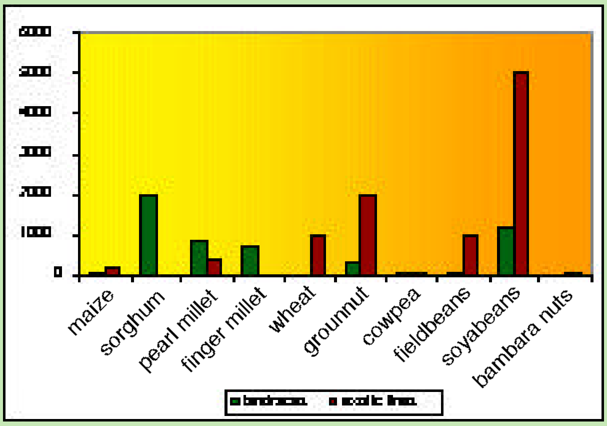
1.8 Recent advances in biotechnology have profound implications for agricultural genetic resources and these need to be addressed by the NBSAP process.

1.9 Expanding global trade increases access to biodiversity for countries, but the potential hazards to agricultural genetic resources need to be addressed by the NBSAP process.

Principle 1.1 Baseline Information needs to be strengthened.

The primary task for those concerned with the conservation and maintenance of farm genetic diversity is to understand, collate and make useable all available information on agricultural genetic resources. In order to conserve, it is first critical to know what one has. In the case of international organisations, this may be as simple as a survey of all accessions in a genebank. For most countries, however, the baseline information needed is much broader, as it needs to include both ***in-situ*** and ***ex-situ*** agricultural genetic resources, and information on the status wild relatives of domesticated species.

Up until now, most National Biodiversity Strategies and Action Plans have referred to accession lists in a national genebank, which indeed is an essential first starting point in documenting what has been identified and collected. However, it is now recognised that ***ex-situ*** conservation is not enough. Conservation of wild relatives of crops, and i***n-situ***, on-farm conservation by rural and tribal men and women remains fairly unrecognised and undocumented, yet such recognition and documention is sorely needed.



Zimbabwe has included the following information in their NBSAP: "Zimbabwe is rich in domestic plant genetic resources which include cereals, pulses, industrial and horticultural crops, indigenous and exotic vegetables, roots and tubers, and medicinal plants." Of major food crops in Zimbabwe, the accessions as recorded at left have been made.

The Zimbabwe NBSAP notes that wild relatives of some of these crops also exist, including cotton, coffee, indigenous vegetables, rice, sorghum, pearl millet, finger millet, cowpeas and bambara nuts, but that very little work has been done to document the diversity and distribution of these wild relatives.

At present in Zimbabwe, some farmers still use landraces of traditional crops such as sorghum, millet, cowpeas, bambara nuts, pumpkins and water melons for food security. However, agricultural commercialisation has adversely affected this practice. A number of initiatives have been mounted to arrest this trend by government and non-governmental organisations, which include:

- Mapping the distribution of local landraces and documentation of traditional knowledge systems in order to facilitate their on-farm conservation, by the Gene Bank of Zimbabwe.
- The promotion of on-farm conservation of traditional landraces of sorghum, pearl millet, cowpeas, and bambara nuts by ENDA-Zimbabwe; and
- The promotion of in-situ conservation and sustainable utilisation of traditional vegetables and fruits by the Community Technology Development Association (COMMUTEC)

These efforts have been rather uncoordinated, however, and the NBSAP notes a need to develop capacity in the identification, documentation, conservation and utilisation of these landraces and to coordinate the efforts of the different actors. Additionally, more information on farmer cultivation and storage of landraces is needed. As well, there is a need for a central depository of all agriculturally important plant and animal genetic resources that is linked to all other depositories.

BEST PRACTICES

Cataloguing, characterising and databasing genetic resources
Making information available

Best practices in this regard require means of cataloguing, characterising and databasing genetic resources, and making this information accessible to end users. For efforts to reach out to rural communities, new methodologies are constantly being developed and tested to utilise farmer variety names, to use farmers' understanding of breeding characteristics in characterisation, and to develop coalitions of groups within a country to build appropriate databases.

The initial starting point must be to measure the amount and distribution of farm genetic diversity maintained ***in situ*** by farmers. One of the methodolgical problems that faces any conservation initiative is to decide what kind of diversity is to be measured and analysed. A key element in understanding farm genetic diversity is to understand the relationship between what farmers recognise or name as a variety and the genetic distinctiveness of this unit. In many cases, farmer-identified varieties may be a good first approximation of genetic diversity and its characterisatio. An exemplary national experiences in this regard can be found in the Ethiopia Flora Project, which developed capacity on plant taxonomy and collection of intra-specific crop diversity.

On-farm research is essential in the characterisation process, and may turn up some surprising results. For example, in the case of the sponge gourd in Nepal, farmers only tend one or two plants of this out-crossing plant. Thus, the "population" is really an entity that is maintained at a village level, not an individual farmer level (Pandey et al 2001).

With respect to livestock races and breeds, which are more genetically uniform than plant landraces, use of local names is more problematic. In pastoral areas such as the West African Sahel and Central Asia, individual breeds range over many countries and tend to have a different name in each region (Blench, 2001). Nonethless, great strides have been made in recent years in developing a global domestic animal database (see DAD-IS in Tools, next page).

In addition to collecting information and cataloging accession, sharing it within a country is also important. There is a growing realisation that material placed into national genebanks should be able to be withdrawn, as well, by local people for use in their on-farm breeding programmes, and protocols are being developed in some countries to make national genebanks available to farmer groups on request. Brazil, for example, has initiated a study on biological characterisation and means of cataloguing accessions available in its germplasm banks, with the aim of making this available through an information service. Ethiopia's Biodiversity Institute, with its 50,000 accessions of over 100 crop species, also focuses on programmes to assist farmers to conserve and use landraces, including those which it maintains in its accessions but which may have been depleted on-farm by drought (Worede et al 2000)

TOOLS:

- IPGRI has a number of resources available in plant genetic resources for agricultural and biodiversity planners in this regard:
  http://www.ipgri.org
- A large number of on-line publications and newsletters in relation to crop genetic resources can be found at the IPGRI publication page:

http://www.ipgri.org/publications/publist.asp

- In particular, for devising systems of in-situ conservation of agricultural genetic resources, the following publication is recommended:
  Jarvis, D.I., L. Myer, H. Klemick, L. Guarino, M. Smale, A.H.D. Brown, M. Sadiki, B. Sthapit and T. Hodgkin. 2000. A Training Guide for In Situ Conservation On-Farm. Version 1. International Plant Genetic Resources Institute, Rome Italy. Available by download at: http://www.ipgri.cgiar.org/publications/pubfile.asp/ID PUB=611)
- The Food and Agriculture Organisation of the United Nations is taking a lead on data gathering and exchange in relation to farm animal genetic resources.
  http://www.fao.org/agriculture
  or
  Animal Genetic Resources Group, Animal Production Service
  Agriculture Development
  Food and Agriculture Organization of the United Nations
  Viale delle Terme di Caracalla
  00 1000 Rome, Italy
  Telephone: (39 - 6) 5225 - 3364
  Facsimile: (39 - 6) 5225 - 5749
- DAD-IS (Domestic Animal Diversity Information System) is a communication and information tool developed by FAO to be used by countries as a clearing house for information and data, offering a secure system that gives countries control over collating, releasing and maintaining their data, and an element of a strategic framework for the management of farm animal genetic resources.
  http://dad.fao.org
- Conservation of wild relatives. An exemplary set of Guidelines for southern India on *in-situ* conservation of wild relatives and related taxa of cultivated plants are offered online, including case studies (http://ces.iisc.ernet.in/hpg/cesmg/situfin.html#SEC1). The guidelines are well designed and applicable to much of the region, and beyond.

Principle 1.2 Identify ecosystem management practices and associated techniques and policies to promote positive and mitigate negative impacts on farm genetic resources.

Farm genetic resources have been conserved over millennia through social systems that reinforced conservation because it was useful. The maintenance of diversity in local varieties or breeds depends both on natural selection and on farmer management, or “human selection”. In order to develop a cohesive national conservation strategy, it is important to understand the ways in which these two interact and their relative importance. A challenging environment- as in mountainous countries with a range of rapidly changing soil types and drainage characteristics- will tend to favour the maintenance of within-variety diversity. Farmers themselves, regardless of the physical environment, may be a force for variation: farmers may seek variation in some characteristics such as maturity time, while trying to eliminate it in others, such as flavour. The final determining force in on-farm conservation is the seed supply system within a country, and this is clearly an area where national agricultural policy has a large influence. Seed supply systems and the ways in which farmers select, keep and exchange seeds are critical to on-farm genetic diversity patterns.

Modern cultivation has threatened the age-old bonds between local farmers and traditional crops. Thirty years ago, up to 75 varieties of millet, sorghum, lentils, pigeonpea and cowpea were grown in the Deccan region of India. The advent of hybrid seeds, chemical fertilisers, bore wells, and government loans has since lured many farmers into gambling on cash crops like cotton and sugarcane — sometimes tragically (Lumb 1988).

As farm genetic resources are being lost, national biodiverstiy planners need to assist agricultural policymakers to identify the practices, techniques and policies that can stem this loss.

Farm genetic resources by and large exist within farming systems managed by people, and cannot be conserved in the same way an ecosystem can be protected. In many respects, diverse farming systems that promote farm genetic diversity are a product of risk-averse farmers who bank on diversity rather than take risks with monocrops and high yielding crops. Such farming systems are dynamic, and cannot be conserved by trying to "freeze" development. As mentioned with respect to Zimbabwe, agricultural commercialisation will often adversely affect on-farm genetic conservation, when landraces are replaced by commercial seed varieties. The introducion of irrigation, which permits more uniform growing conditions that improved varieties require, may also lead to loss of on-farm genetic resources. Agricultural policy should not try to prevent the introduction of modern techniques, but should offer farmers greater room for making their own decisions, and integrating the best of traditional practices and modern technologies. At the end of the day, it is not the landraces themselves that is most important to conserve, it is the process of farmer innovation and adaptation to local conditions that needs support.

BEST PRACTICES

- Early warning systems of genetic erosion
- Participatory/decentralized breeding
- Seed and livestock/diversity fairs
- Strengthening cultural identities
- Community gene banks
- Improve seed storage practices
- Access to credit for farmers planting landraces
- Increase demand for landraces

Some effective practices that have been identified to help stem on-farm genetic diversity losses include early warning systems among farmers, and participatory breeding with farmers and plant breeders. Farmers will be the first to know when particular varities or landraces are beginning to disappear, and will know what desirable traits should be salvaged and incorporated in improved seed. In Nepal (Rijal 2001) farmers did not want to contribute to community gene banks, as their cultural practice has always been that farmers keep their own seeds. Farmers did feel, however, that it would be useful to maintain a registry of local varieties throughout the community, and to keep track of who has which variety and whether the variety was increasing or decreasing in the village. Through the initiative of a local non-governmental organisation (NGO) LiBird, and the National Agricultural Research Council, such a system, maintained by the farmers themselves, has been put in place.

Seed and livestock diversity fairs are also helping to recover and conserve agricultural genetic resources (see India, box). Fairs and exhibitions may not be a part of a community's traditional activities, but they build off of historical practices of exchanging seeds, and linked agricultural/cultural festivities. (Gonzales 2000) For example, in the Cuzalapa valley of Mexico, farmers constantly exchange small lots of maize seed, providing seed for planting at any time of the year and introducing new diversity into existing landraces (Louette ***et al*** 1997).

Community seed banks, and improved local seed storage practices, are an important form of support to ***in-situ*** conservation. For example, in Tigray, Ethiopia, farmers have established a community seed bank that currently holds a wide range of traditional crops. The seeds are selected by the local farmers based on specific cultural, technological, and ecological criteria. In a nation-wide project, a network of twelve community ‘genebanks” are linked both to the national genebank and to small local seed storage systems such as clay pots, rock hewn mortar and underground pits.

In the past, farmers were more likely to receive credit from banking institutions when they invested in improved varieties and modern technologies such as tractors and irrigation. A new paradigm might emerge, for granting credit to farmers for planting landraces and conserving traditional systems of farming.

Increasing the demand for landraces is possible, and has succeeded in a modest way in a number of situations, as long as their use is integrated into improving the lot of the farmer (see Peru, box).

It should be noted, however, that change is inevitable, and many of these “best practices” can potentially have negative impacts. For example, through a seed diversity fair, farmers may decide to abandon their local races, and work with seed from other locations. Again, however, the fact that the farmer is applying his or her accumulated understanding to improving farm genetic resources is a “best practice” which ensures genetic diversity in a broad sense, despite what may occur with a particular landrace.

The Deccan area of India succeeded in bringing farmer participation to the ongoing NBSAP process, which proved to be useful also in reviving nearly extinct crop varieties. A biodiversity festival was organised in which about 70 villages around the Zaheerabad region of Deccan were visited by bullock carts displaying seeds of a variety of crops. Discussions with farmers took place in each village about agrobiodiversity that they planned to conserve, enhance for sustainable use, and equitably distribute. This resulted in a BSAP for agrobiodiversity conservation for each village.

Key participants reported that the response to the festival had been enormous, including from many of the larger, cash-cropping farmers who were sceptical of the return to traditional seeds, but nevertheless were sufficiently impressed to promise to try them. In many villages, elders recounted the ways their lives were better when they had the old seeds, now nearly gone.

The discussions amongst the farmers brought up many crucial benefits of mixed organic farming: an increase in the nutritive values of the food they consumed, a variety of fodder available for their cattle, an enhancement of soil fertility and prevention of its erosion, an increase in immunity against illnesses and disease, a decline in pest attacks, and a means of managing climatic unpredictability. Many challenges and constraints were also voiced, one of the biggest ones being the shortage of farmyard manure. Over the years it has become increasingly difficult for farmers to maintain their livestock. There has been a reduction in the availability of fodder. Grazing lands previously available to rural communities are often appropriated for various developmental purposes, with little thought about the consequences to villagers. What also came up repeatedly was the need for a change in government policies to boost the marketing value of traditional varieties, by even including them in the public distribution system.

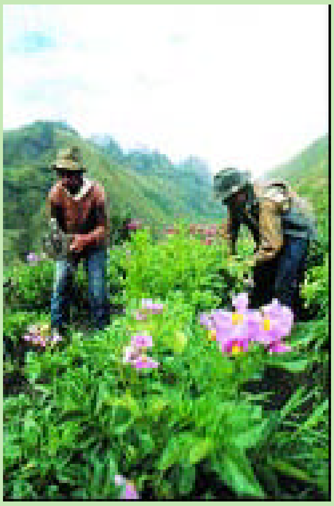
from S. Padmanabhan and A. Kothari, Kalpavriksh - Environmental Action Group, pers communication

TOOLS:

- Early warning systems, and participatory/decentralised breeding both require the expertise and participation of farmers, working with national breeding programs. Again, one of the best tools for this are the resources being provided by IPGRI: http://www.ipgri.org.
  including their large number of on-line publications and newsletters: http://www.ipgri.org/publications/publist.asp
  and, in particular, for devising systems of participatory breeding the following publication is recommended:
  Jarvis, D.I., L. Myer, H. Klemick, L. Guarino, M. Smale, A.H.D. Brown, M. Sadiki, B. Sthapit and T. Hodgkin. 2000. A Training Guide for In Situ Conservation On-Farm. Version 1. International Plant Genetic Resources Institute, Rome Italy. available by download at: http://www.ipgri.cgiar.org/publications/pubfile.asp/ID PUB=611)
- Seed and livestock diversity fairs: a good description can be found in Gonzales 2000.
- Developing demand for landraces: Ethiopia in particular has experience in promoting greater use of landraces in the informal market, as described in this article:
  Worede, M., T. Tsemma and R. Feyissa. 2000. Keeping diversity alive: an Ethiopian perspective. pp. 143- 161. In: Brush, S.B. (ed.). Genes in the Field. Lewis Publishers, Boca Raton, FL.

Principle 1.3 There is a need to develop linkages between agricultural genetic conservation and use and benefits sharing.

The practices above, in principles 1.1 and 1.2 depend on the cooperation and participation of the state agricultural research sector, and of farmers. In order to make these practices sustainable, appropriate economic incentives need to be in place. This requires a proper valuation of the private and public functions of biodiversity. But first, adverse measures need to be removed.



Peru: While many kinds of modern seed improvement schemes lead to erosion of genetic diversity, as uniform modern varieties are promoted, an interesting project in Peru showed another way forward. To combat low yields of indigenous potato varieties in the highlands of Peru, a programme was launched to produce better seed quality- but instead of using modern potato varieties alone, it relied on varieties that farmers were already planting and valuing, based on prior surveys; this included 20 modern and 16 native varieties. Good clean quality seed was produced, and while the researchers fournd that it only increased production by 20%, farmers were willing to pay two to three times the normal price for this seed, but in small quantities and in the first year. Farmers bought the seed and used it to improve their own landraces; with the clean seed and new genetic material, they felt that they could manage to markedly improve their production for the subsequent five years. In this way, a demand was created and fulfilled- not a high volume market, but a very specialized, low volume but high value demand, for clean good quality seed which incorporated landrace characteristics.

from Thies, 2000

South Africa: The measure for the promotion of crop diversification at the farm level applied in South Africa to date has been the removal of agricultural subsidies. For example the Marketing of Agricultural Products Act 47 of 1996 came into effect in January 1997 and is based on the view that state intervention in agricultural markets should be the exception rather than the rule. Another example is that with the termination of the General Export Incentive Scheme in July 1997, export subsidies with respect to agricultural products are now zero. These radical reforms have had two aims, namely, increasing efficiency and productivity, and increasing opportunities for access to markets for small and medium-scale farmers.

BEST PRACTICES

- Removal of adverse subsidies for genetic resources
- Payment for ecological services
- Benefit-sharing agreements
- Market creation and support for commercialisation of biodiverse products

Agriculture is often an intensively subsidised economic sector. Therefore many prices are distorted and do not reflect the real costs of production. In many developed countries, large subsidies are applied to the agricultural sector. These have often been duplicated in developing countries, promoting the use of purchased seeds and other agricultural inputs. For many years, government seed programmes have concentrated almost exclusively on main staple crops and improved varieties. As the processes of seed multiplication, certification and marketing are often heavily subsidised, these policies favour the use of modern varieties. None of this can be said to benefit the conservation of genetic resources, and the inefficiencies of government seed programmes have made many of these largely ineffective (GTZ 2000). The removal of subsidies in countries such as South Africa (see box) provides a model for other countries.

Activities that can help countries to remove subsidies that have an adverse impact on the conservation of agricultural genetic resources are detailed in a series of publications by GTZ (see tools). Making subsidy systems more transparent, having strong national programmes of agricultural genetic resource conservation, and cooperating with other countries to multilaterally remove supports are some of these.

In some cases, countries have replaced adverse subsidies with "payments for ecological services": environmental funds and public financing for positive incentives. If indeed genetic diversity can only be conserved ***in-situ*** by maintaining traditional farming systems, and yet this is not wholly advantageous to the farmers, then countries may need to consider compensating or supporting farmers for maintaining certain practices. China has had some experience with this undertaking, as has Austria (see boxes).

In the agricultural sector much thought has been devoted to developing international mechanisms for sharing the benefits of genetic resources. The road to commercialisation of agricultural genetic resources is often long and convoluted, such that there is not a ready source of income to be divided up between ***in-situ*** conservators and those who eventually may earn money from commericalising the conserved resources. Yet there should be some means of linking present-day conservators with future benefit streams The current vehicle being considered in international negotiations is a legally-binding treaty is called the ***International Undertaking on Plant Genetic Resources*** (IU). It covers major food crops and forages developed in farmers' fields and stored in public gene banks. It aims to ensure the conservation, sustainable use and 'free flow' of the genetic resources of these crops and forages

China: The Chinese government has taken a direct role in the conservation efforts for the Hu-sheep. The remainder of the endangered Hu-sheep population has been placed into the hands of farmers, who are not allowed to sell, slaughter or exchange any of the animals without official permission, although they are compensated with a subsidy. In the core area of the project the keeping of any other type of sheep is prohibited. A herd book is kept and the lowest performing individuals are eliminated.

from Kölher-Rollefson, 2000

and, when they are used commercially, that farmers in developing countries receive a fair share of the benefits. The text of the International Undertaking is still being agreed upon by the international community, as of October 2001.

Creating markets for biodiverse agricultural products should be the most direct means of benefit sharing, providing immediate benefits to producers. But, while market incentives for organic agriculture are well established, the same is not yet true for genetically diverse agriculture. Yet, there is a need, within organic agriculture, for varieties that can produce under conditions of low agricultural inputs.

Local initiatives appealing to cultural pride may be a highly constructive tool, and one that should be promoted. One example given among the case studies of the Convention on Biological Diversity is that of a regional initiative to reinstitute a local cheesemaking industry from the endangered Aubrac cattel breed in France (http://216.95.224.231/agro/Casestudies.html).

A key ingredient of appropriate market incentives is that a larger share of profits are returned to producers rather than remaining with middlemen. In India, the Deccan Development Society has established an alternative market under their control where prices are more advantageous to farmers.

Austria: Austrian agriculture is characterised by a wide diversity of small farms, with almost half facing the challenging management problems of farming in mountainous regions. Whereas in most other European countries agricultural enterprises tend to be more intensive, in Austria an average farm is about 13 hectares, and an average dairy farmer has seven cows. Instead of subsidising agricultural inputs, Austria offers its farmers incentive payments for such activities as practising organic agriculture, NOT applying agricultural inputs or using high-yielding, intensive farm practices, and maintaining natural areas on-farm. The total number of participants in the programme own 64% of Austria's agricultural and forest landholdings. Requests for support for organic farming has been the most popular form of participation. Austrian policy makers have concluded that the programme is a success, and key to this success has been the fact that it has been broadly inclusive of all agricultural land, and all farmers. Famers are now much more sensitive and aware of environmental and conservation issues. One of the primary benefits to the country, besides supporting its farming sector, is that a healthy, green farm landscape is a major tourist draw for Austria.

from Thies, 2000

- An excellent series of publications on agrobiodiversity conservation are available at this web site, including a useful discussion of incentive measures, in the publication by Evy Thies (2000).
http://www.gtz.de/agrobiodiv/english/pub/pub.htm

- With respect to payment for ecological services in conserving genetic resources, calculations have been made for the minimum land area needed to conserve traditional varieties, and ways of determing appropriate level of compensation, based on the opportunity costs of foregoing conversion to modern varieties; see: Virchow, D. 1999. Conservation of Genetic Resources. Costs and Implications for a Sustainable Utilisation of Plant Genetic Resources for Food and Agriculture. Springer Verlag. ISBN: 3-540-65343-0.

- Developments with respect to the International Undertaking on Plant Genetic Resources can be monitored by visiting the relevant United Nations Food and Agriculture Web page at: http://www.fao.org/ag/cgrfa/iu.htm

Principle 1.4 Strengthening community management of agricultural resources increases plant and animal diversity essential for secure livelihoods.

A number of the best practices listed before are targeted to communities, for example, seed and diversity fairs, strengthening cultural identities, community gene banks , and improving seed storage practices.

In addition to these more direct "interventions", it is critical for both agricultural and biodiversity planners to recognise that communities, and community groups, are their allies. Indirect forms of support and planning for community mobilisation, awareness raising and capacity building are also advantageous to biodiversity conservation.

BEST PRACTICES

Encourage and facilitate formation of community based groups/community based organizations (CBG/CBOs), who participate fully in planning and management of Agricultural Genetic Resources, and evaluation.
Use of mass media and other avenues to regularly provide information relative to Agricultural Genetic Resources.
Incorporate Agricultural Genetic Resources in the educational system.

Integrating initiatives to conserve agricultural genetic resources with community develop-

Ethiopia: A partnership between breeders and the gene bank in Ethiopia is returning farmers' varieties to areas from where they had disappeared. The best yields are selected from seed originally collected from the area where the reintroduction will take place and mix it to form a multiline mixture. On land which had been planted to pulses as in traditional fertility management, these composites yielded better than their counterparts, improved varieties planted in the same area with the application of the recommended amounts of fertilser

The farmers are also interested in new seeds and knowledge. Moreover, they stress the importance of transmitting the selection skills to new generations. This ensures that technological knowledge and skills for genetic resources conservation are retained in the community. Institutional memory is sustained through generations of social change (Berg, 1996).

ment will increase the capacity of farming communities to manage their resources in a sustainable manner. For example, in the model given on page 14 of the Deccan region of India, a roving festival instigated a conversation among farmers on the nutritive value of the foods they consumed, and the quality of fodder available for their cattle. Development that builds the capacity of communities to address these agricultural production issues, including using diverse farm genetic resources, has benefits all around.

Poverty and the ability to save seed are strongly linked. In countries where 60 - 90% of the seed planted is farmer produced and exchanged, poor households have less capacity to save seed as they more frequently need to sell or consume their entire harvest. Poor farmers often have to rely on whatever seed source they have access to at planting time, and are often not a part of the same social network of seed exchangers, particularly if they are women (Almekinders 2001). Yet in some communities, it is the older and poorer women-farmers who know the most about native varieites (Zimmerer 1991). The erosion of this knowledge may be stemmed by encouraging inclusive community groupings where benefits and knowledge - and genetic material- can be exchanged.

The public, be they farmers, consumers or policy-makers, often are not aware of their cultural heritages of farm genetic resources, and their value in sustainable agriculture. The consumption of local varieties and minor crops can be promoted by pointing out their value in the context of cultural heritage and identity in combination with nutritional values (Almekinders 2001). Sweet potato snacks are promoted in Bagio, the Northern Philippines, through publications, newsletters and events which stress their relationship to the subsistence of small-scale farmers in the region, and their role in providing revenue for farmers maintaining sweet potato diversity.

TOOLS

- Chapter 7 of the following publication provides a framework for working with communities and organisations to develop on-farm conservation initiatives:
  Jarvis, D.I., L. Myer, H. Klemick, L. Guarino, M. Smale, A.H.D. Brown, M. Sadiki, B. Sthapit and T. Hodgkin. 2000. A Training Guide for In Situ Conservation On-Farm. Version 1. International Plant Genetic Resources Institute, Rome Italy. available by download at: http://www.ipgri.cgiar.org/publications/pubfile.asp/ID PUB=611)
- The following two publications contain useful discussions of community-level management of farm genetic resources:
  Köhler-Rollefson, I. 2000. Management of Animal Genetic Diversity at Community Level. GTZ, Eschborn.
  Almekinders, Conny. 2001. Management of Crop Genetic Diversity at Community Level. GTZ, Eschborn.
  They can be downloaded at: http://www.gtz.de/agrobiodiv/english/pub/pub.htm
- As part of the In Situ Agricultural Biodiversity Conservation Project of the Intermediate Technology Development Group (ITDG) and the Overseas Development Institute, UK (ODI), an annonated bibliography of on-farm management of crop genetic diversity is available at http://www.ukabc.org/abc_bibliog.pdf

Principle 1.5 Develop appropriate partnerships.

Just as communities (Principle 1.4) and the private sector (Principle 1.6) have distinct and critical roles to play in the conservation of agricultural genetic resources, it should be recognised that in almost every successful campaign to promote on-farm conservation, a broad array of institutions have taken a role. Part of a national strategy should be to give official recognition and support to those institutions playing an intermediary role between communities and government agencies.

NGOs and research organisations can help to facilitate local, regional or national participation. They vary greatly in their aims and capacities, from being highly technical or delivery-oriented, to acting as advocates for community rights or environmental conservation. Such organisations may be particularly effective in developing a special focus on supporting the rights of traditionally-excluded constituencies: smallholder and subsistence farmers, women farmers, etc., and ensuring that they have the opportunity to participate in decisions about proposed programmes.

BEST PRACTICES

Develop partnerships among farmers, policymakers and researchers and all other stakeholders in conservation and useof agrobiodiversity.

Have a special focus on traditionally-excluded constituencies: smallholder and subsistence farmers, women farmers, etc.

Tools

- Certain international and regional NGOs focus on providing guidance on these issues at national and community levels. Links to many of these can be found at: http://directory.google.com/Top/Science/Environment/Biodiversity/Agricultural/ or

Partnerships in **Mexico, Morroco, Nepal:** To understand and support the mechanisms of *in situ* conservation on-farm, the International Plant Genetic Resources Institute, together with national partners in nine countries, has undertaken a global project on "Strengthening the Scientific Basis of *in situ* Conservation of Agricultural Biodiversity". As diverse as each country project is, most include key collaborations with NGOs, national agricultural research centres, universities and community organisations. Three of these are described here:

The project in Mexico is situated in the centre-north of the Yucatan peninsula, an area where almost 50,000 families still practice a form of shifting cultivation with a mixture of maize, lima bean, cassava, yam, squash and other crops, all of which are cultivated in a multicropping system with large genetic diversity. Yet this farming system is threatened with disappearance, and any modification of the system will have serious implications for crop genetic diversity. A group of agricultural research organisations and universities from the national level work with a local NGO and the government extension service on participatory plant breeding, agro-ecosurveys, and farming system research to support existing *in-situ* conservation.

In Morroco, a unique array of agro-ecosystems with an equal range of genetic diversity for certain crops is under threat. The project has three sites, one in the Atlas Mountains, one in an oasis area and one in the Rif Mountains. The crop focus is on barley, durum wheat, faba bean alfalfa and bread wheat. The NPGRP, part of the NARs, works with the extension service and a number of NGOs.

Nepal is a rich centre of crop genetic diversity reflecting extreme ranges in altitude, ecological variation, antiquity of agriculture, and numerous ethnic and cultural groups. Three regions have been selected for the project, representing high, medium and low-altitude crop production systems. Upland, rainfed and irrigated production systems have been included. Major crops addressed in the project include rice, finger millet, barley, buckwheat, taro, sponge gourd and pigeon pea. The project focuses on participatory approaches to research, conservation, and plant breeding. The partners in Nepal aim to find an institutional and professional balance among the national agricultural research service and NGO researchers in implementing the project.

from Jarvis and Ndungú-Skilton, 2000

via the “links” on the www.ukabc.org web page. Some of those with well-developed capacity in facilitating advocacy and action on agricultural genetic resources for food and agriculture are:
Intermediate Technology Development Group International
Action Aid
ETC Group, International
AS-PTA, Brazil
Semillas, Colombia
Acción Ecológica, Ecuador
GRAIN, International
PELUM network, Southern and Eastern Africa
Navdanya, India
UBINIG, Bangladesh
SEARICE, Philippines
MASIPAG, Philippines
Seedsavers Network, Australia
Pro Specie Rara, Switzerland
Arche Noah, Austria
HDRA Heritage Seed Library, UK
SAVE, Europe
IPBN, International (Indigenous Peoples Biodiversity Network)
Seed Savers Exchange, USA
CLADES, Latin America
IATP, International

- One approach to develop common purposes among different organisations and a definition of each partners' responsibilities is to use project planning and management tools in stakeholder meetings. A sourcebook that explains the use of such tools is available at:
  http://www.worldbank.org/html/edi/sourcebook/sba102.htm

Principle 1.6 The private sector should take responsibility for ensuring that their private activities support the conservation of agricultural genetic resources.

Presently, it is the informal seed sector in developing countries that ensures food security for the rural population and sustains local management systems for plant genetic biodiversity conservation. The farm animal breeding market is not also not very commercialised; control of breeding animals is determined more by cultural practices than by market potential. Many of these “informal” practices are highly advantageous for biodiversity conservation. For example, in Rajasthan, India, a village bull is traditionally selected and maintained by the community as a whole. Villagers pool their resources to purchase a bull from a reputed breeder, share the upkeep by providing a fixed amount of grain and green fodder per household, employ a keeper, and make a joint decision on when and how to dispose of the bull to avoid inbreeding. National agricultural and biodiversity planners should support such informal sector and cooperative village economic ventures, at the same time as recognising a future role for the formal sector.

Undoubtedly, in the future, the formal private sector will take on a stronger role. If substantial incentives are to be provided to farmers conserving agricultural biodiversity, most of these incentives will need to be provided by the private sector. It will be up to government policy to lay out the rules and regulations to ensure that this is so. With respect to the seed and livestock breeding industries, the government has a critical role to play in crafting and enforcing laws and regulations; ultimately it is the state that sets standards and establishes the incentives and penalties to assure that these are achieved.

BEST PRACTICES

- Support complementarities between the formal and informal seed sectors
- Modify regulatory and legal frameworks of formal seed supply systems, especially with regard to registration and certification.
- Develop a coherent Agricultural Sector Programme and a National Seed Policy in which the importance of the informal sector is recognised.
- Private sector development:
  - a. Financial conditions (credit/investment, tax and seed import/export procedures) favourable for (small-scale) private initiatives
  - b. Administrative and legal conditions favourable for small-scale private enterprises

Large-scale, government-led seed industries in biodiverse developing countries have rarely functioned well. The formal seed sector has not been able to address widely varying agro-ecological conditions or the needs and preferences of small-scale farmers. In many cases, farmers produce in many cases seed of similar or higher quality and at more affordable costs than the seed programmes. However, informal systems also have severe limits. In particular, low yields or crop failures impact heavily on seed availability. Once collapsed, the local system does not easily recuperate. In such a situation, local varieties are easily lost and replaced by relief-supplied seeds (GTZ, 2000).

Better interaction between the formal and the informal systems can serve both. The farmers' demand for seed in developing countries is complex and diverse. It is not realistic or efficient for the formal seed sector to aim at covering the total seed demand. Instead of

Canada: In the New Brunswick province of Canada in the late 1970s there were no mills for processing bread wheats. All flour was imported- although it had been grown in the area justa hundred years ago. A group of enterprising people put together the Speerville Mill Cooperative and began milling wheat. The cooperative wished to encourage local growers to produce organic flour, for a high-value, regional market. As farmers began to plant wheat again, the New Brunswick Department of Agriculture assisted by beginning milling wheat farm trials, at the request of the milling cooperative. Varieties that could be grown under organic conditions were identified. But as demand has outstripped supply, the Speerville Mill began to think seriously about how to increase production. Farmers, at the same time, were expressing dissatisfaction with the most common milling wheat variety, which had been bred in western Canada under dry conditions. The variety yielded poorly and suffered weed and disease problems under the humid, maritime conditions of New Brunswick. Moreover, it had been selected for response to conventional management (using herbicides, synthetic fertilisers, fungicides and other pest control products) and did not respond as well as was hoped in organic production.

The Martime Certified Organic Growers and Speerville Mill, in cooperation with the New Brunswick Department of Agriculture, initiated a new set of trials on organic farms, using a diverse collection of wheat varieties, including various "heritage" wheats from the Canadian Genebank, Seeds of Diversity Canada, farmer-saved seed and seed dealers.

While trials are still ongoing, farmers are realising that not all characteristics can be found in one variety. Nutrient quality has been an important criteria to the farmers and to the mill, and it was noted that yield is often inversely related to protein content. In 1998, all growers supplying Speerville Mill grew at least two varieties of wheat.

from J. Scott, in Almekinders and De Boef, 2000

Bangladesh: The Bangladesh-German Seed Development Project supported by GTZ, is implemented with the Bangladesh Agricultural Development Corporation (BADC), which traditionally has been the organisation responsible forfertiliser supply to agriculture. With regard to the informal sector, the project evaluates the potential for small-scale seed enterprise development. It specifically targets the development of organisations and capacities of small farmers in Bangladesh to produce, process and market seeds. It is also important in relation to the re-orientation of the perceptions of public sector technicians, in particularly those in BADC.

replacing the informal sector, the formal sector can build on farmers' capacities and knowledge regarding local conditions and seed selection to address more effectively the seed demands of small-scale farmers. The informal system can be significantly strengthened, for instance, by introducing improved genetic materials and adapting improved seed technology to local conditions. A more diverse portfolio of varieties and seeds provided by the formal sector offers farmers a wider choice. This enhances the use of crop genetic diversity in farmers' fields.

The regulatory and legal framework of the national formal seed system in many countries becomes a factor that limits the development of the informal seed system. National seed regulations are usually based on international standards, which are often useless or incompatible with farmers' reality. They impose restrictions on free exchange and marketing of seeds. The combination of compulsory variety registration and seed certification, as practised in European and other countries, is an especially heavy constraint both on the efficient functioning of the formal seed sector and on the development of alternative seed systems. At present the seed policy in many countries is restricting informal seed sector development. A legal framework has to support a pluralistic variety of seed supply, with farmers being served by a number of institutions, including those in the private sector. On-farm seed production and exchange, maintenance, development and registration of local varieties should not be restricted by national seed policies. In a system with multiple seed sources to select from, seed control or certification may not be relevant for all seed planted, but can concentrate on, for instance, breeder and foundation seed.

It is critical to support activities to improve seed production and marketing relating to farm genetic resource conservation. The opportunities for successful small seed enterprises need careful analysis: Seed enterprises can only be sustainable if seed demand is sufficiently large and constant. Yet conservation of biodiverse farming systems requires a diverse portfolio of genetic resources.

It is difficult to find an exemplary model of private sector involvement in agricultural genetic resource conservation; it may be that these models are only on the horizon, currently under construction. But if we can take a milling cooperative and farmer groups as representing the private sector, there are interesting case studies (see box, Canada) which may serve as good models. Some exemplary development projects (see box, Bangladesh) also suggest the way forward.

TOOLS

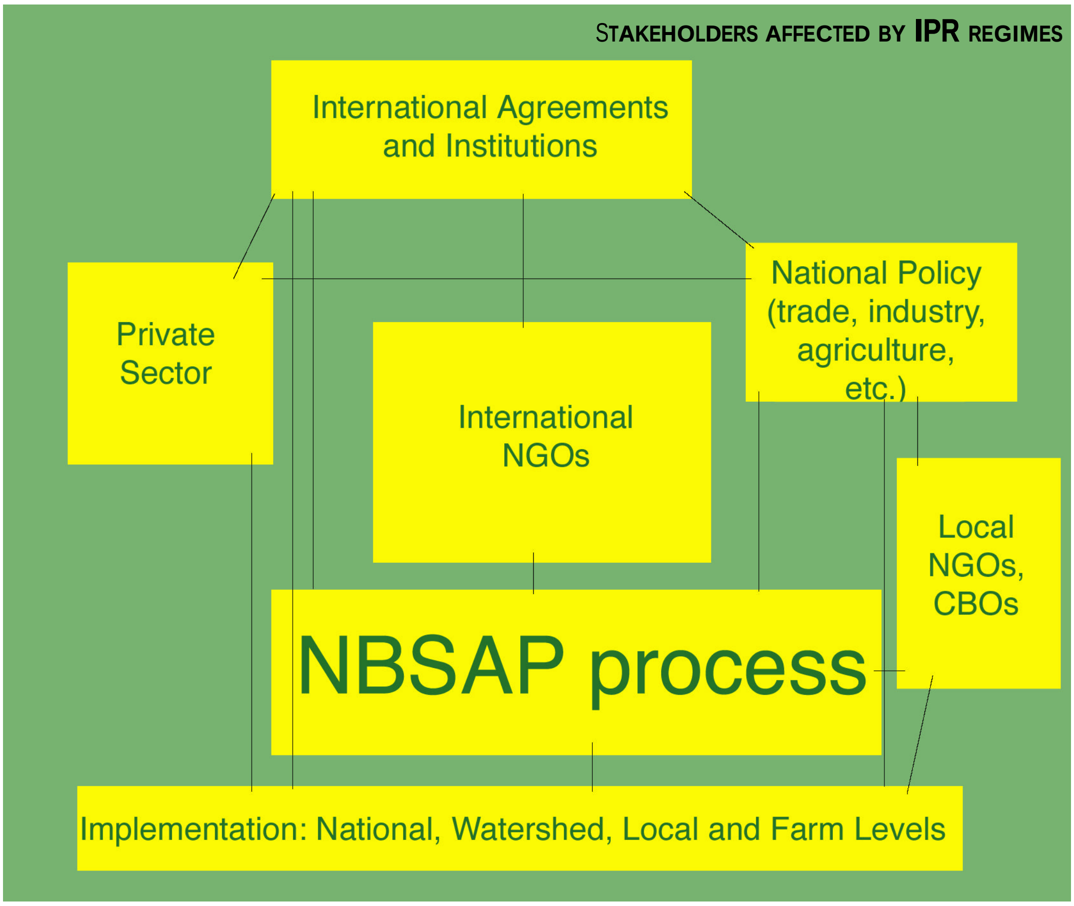
- much of the foregoing information is derived from the excellent small booklet produced by GTZ, "Support for the Informal Seed Sector in Development Cooperation - Conceptual Issues" available online at http://www.gtz.de/agrobiodiv/english/pub/pub.htm.

• A useful discussion of seed laws can be found in:
Louwaars, N. and R. Tripp. 2000. Seed legislation and the use of local genetic resources. pp. 269-275 in C. Almekinders and W. de Boef, Encouraging Diversity. ITDG Publications

Principle 1.7 Issues of access, benefit sharing and intellectual property rights are central to the NBSAP process so planners need to carefully consider the position of various stakeholders.

Many other working groups related to the Convention on Biological Diversity or the United Nations Food and Agriculture Organisation are addressing these issues in depth, which we will not try to do here. Nonetheless a "guide to best practices" for managing agricultural resources in biodiversity-friendly ways needs to touch on the subject as well, as it could potentially have tremendous influence on future practices. We have tried here to simply distill the critical points to which national biodiversity planners will need to pay attention.

At present, the recognition of intellectual property rights for farmers' varieties and traditional knowledge of agrobiodiversity is problematic. Existing laws are clearly not able to protect the use of traditional knowledge. Traditional knowledge ***per se*** is "generally known" and therefore cannot be protected under current national and international patent law. In general, only the results of research and development obtained on the basis of traditional knowledge is commercially valuable, and that after many years of research investment. There is discussion of a law dealing with Community Intellectual Property Rights, and also a law dealing with Farmer's Rights. The International Undertaking on Plant Genetic Resources addresses a version of these concepts, in relation to thirty-five staple crops and twenty-nine forage crops. None of these are yet in force, but NBSAP planners should be aware of them, and they should be introduced to stakeholder consultations for consideration.



The CBD does promote a

first step of requiring access-seekers to obtain "prior informed consent" from indigenous and local communities, based on full knowledge and information, before making use of indigenous knowledge or genetic resources.

A fuller discussion of knowledge systems in relation to agricultural biodiversity can be found in section 3.5

BEST PRACTICES

Develop an appropriate and broad stakeholder consultation process (include e.g. ministries, farmers/herders, private sector, lawyers, scientists, NGOs to consider the issues, in relation to national biodiversity strategies.
Develop national policies to support distribution of benefits from IPR to farmers and holders of traditional knowledge.

The diagram on the previous page ("stakeholders affected by IPR regimes") is a first approximation of the key stakeholder groups and their relationship to national biodiveristy planning teams.

National policies on benefit sharing with communities and farmers are still at an early stage. A few countries are experimenting with innovative mechanisms (see box, Ecuador) although there is not as yet much experience with these.

TOOLS

- Developments with respect to the International Undertaking on Plant Genetic Resources can be monitored by visiting the relevant United Nations Food and Agriculture Web page at: http://www.fao.org/ag/cgrfa/iu.htm
- CBD web pages on access and benefit sharing can be found at: http://www.biodiv.org/programmes/socio-eco/benefit/default.asp.
- The Biodiversity Planning Support Programme features a new publication on "Preparing a National Strategy on Access to Genetic Resources and Benefit Sharing, available on line at; http://www.undp.org/bpsp/thematic_links/access.htm#absrbgk, and containing many useful links to national case studies and supplemental material.

Ecuador: From traditional knowledge to trade secrets- the Cartel project in Ecuador

The pilot phase of a project entitled "The Transformation of Traditional Knowledge into Trade Secrets" is underway in Ecuador. The project starts from the premise that biological diversity shares a similar cost structure to that of an information good: extremely high opportunity cost in the maintenance of habitats. It is argued that in a parallel to patents, copyrights and trademarks, which are accepted as instruments to enable the emergence of a market for information goods, oligopoly rights over genetic resources should be allowed to enable the emergence of a market for habitats. Thus the project attempts to achieve a cartelisation of traditional knowledge in Ecuador. It is a collaborative effort by the Inter-American Development Bank and several NGOs. The project sets out to catalogue traditional knowledge and maintains the database at regional centers, which is safeguarded through a hierarchy of access restrictions. After filtering, the knowledge that is not yet public will be negotiated as a trade secret in a Material Transfer Agreement (MTA). The benefits from the MTA are to be split between the Government and all communities that deposited the same knowledge in the database. Quite similar approaches to handle indigenous and local knowledge have been chosen for example in India.

from E. Thies 2000

Principle 1.8 Recent advances in biotechnology have profound implications for agricultural genetic resources and these need to be addressed by the NBSAP process

As with the preceding principle, there are many other working groups considering biotechnology issues, and we cannot do the subject justice in this short guide. Nonetheless, biodiversity planners should be aware of these working groups, and the models presently available to national governments to formulate policies related to biotechnology in agriculture.

BEST PRACTICES

Harmonization of biotechnology, biosafety and biodiversity policies
Provide appropriate incentives to private sector to transfer techniques to enable developing countries to use biotechnology in appropriate ways for sustainable development.

Most of the focus on biotechnology issues right now is on the implementation of the supplementary agreement to the Convention on Biological Diversity known as the Cartagena Protocol on Biosafety. The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. It establishes an advance informed agreement (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol also contains reference to a precautionary approach and reaffirms the precautionary language in Principle 15 of the Rio Declaration on Environment and Development. The Protocol also establishes a Biosafety Clearing-House to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

TOOLS

- The CBD web page on biosafety (http://www.biodiv.org/biosafety/) provides many linkes, including to a simplified list of frequently asked questions: http://www.biodiv.org/biosafety/faqs.asp.
- A new book just recently published by the International Food Policy Research Institute looks at policies affecting the adoption of GM crops in four important developing countries: Kenya, Brazil, India, and China. The author identifies five policy areas in which governments of developing countries can either support or discourage GM crops: intellectual property rights, biosafety, trade, food safety, and public research and investment:
  Paarlberg, R.L. 2001. The Politics of Precaution: Genetically Modified Crops in Developing Countries. IFPRI, Washington D.C. 184 pp.

Principle 1.9 Expanding global trade increases access to biodiversity for countries, but the potential hazards to agricultural genetic resources need to be addressed by the NBSAP process.

Unintentional introductions of alien and invasive species through international trade is posing one of the greatest threats to the world's biodiveristy. Although we do not know all of the pathways by which alien species find their ways to distant shores or fields, agricultural policies and practices are strongly implicated, as can be seen from the following list of pathways, both intentional and unintentional.

•Intentional introductions for: Agriculture, Forestry, Soil conservation, Horticulture, Hunting, Biological control, Research, and Other
•Unintentional introductions through contaminants of: agricultural produce, nursery stock: cut flowers, timber, seeds and inorganic material.
from: the Global Invasive Species Program/Pathways of Invasives project component, available from the website: http://www.biodiv.org/programmes/cross-cutting/alien/links.asp

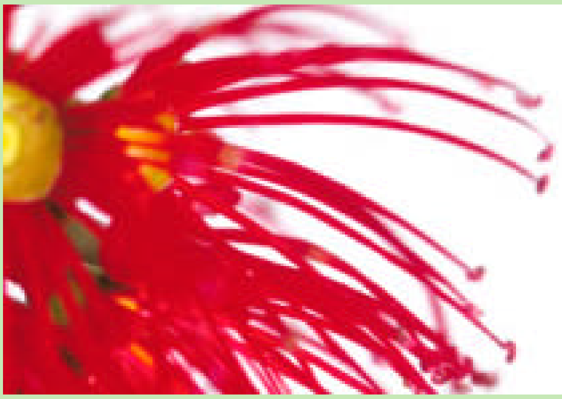
Here again, the number and depth of international and national initiatives addressing alien species issues is tremendous, and national biodiversity planners are best served by being referred to relevant bodies of information.

BEST PRACTICES

National agricultural and biodiversity planners should integrate trade and biodiversity issues into national legislation and regulations

New Zealand: New Zealanders recognise that to preserve the country's flora and fauna, clean air, fresh water, open spaces and green pastures, they must be vigilant against alien invasive species. They have established a BioSecurity Authority to provide greater focus and coordination in the New Zealand Government's programme to protect the health and welfare of the animal and plant populations intheir 268,000 square kilometres, from alien invasions. The Biosecurity Authority is the largest Government provider of biosecurity services in the world. It employs over 80 technical experts and operates well-established frameworks for setting standards and managing associated risks. On the New Zealand Ministry of Agriculture and Forestry Biosecurity webpage (http://www.protectnz.org.nz/grids/index.asp?id=12&area=12), there is a link for producers and growers, which begins:

"Welcome to the Producers and Growers section of the Protect New Zealand web-site. If you are a farmer, horticulturist, or involved in forestry or any other form of primary production, you can find information here about the biosecurity issues facing New Zealand and your business. It outlines what is being done and what you need to know to protect our agricultural economy and our fragile environment."



The website, and programme literature seek to help people identify "creepy crawlies" that they may encounter intheir backyard, in container loads of imported goods or other places, so that they can call and report new infestations before they are out of control.

International cooperation is needed on identification, early warning, monitoring e.g. biological controls

Island states are usually the most vulnerable to alien invasive species, and often can serve as excellent lessons of what not to do, as well as lessons of strong proactive programmes, such as that of the New Zealand BioSecurity programme (see box).

TOOLS

- The CBD web page on alien species (http://www.biodiv.org/programmes/cross-cutting/alien/default.asp) provides basic information and links (http://www.biodiv.org/programmes/cross-cutting/alien/links.asp) to related websites.
- From this links page, the "IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species" is available, with many practical actions suggested for national governments.
- The New Zealand Ministry of Agriculture and Forestry Biosecurity webpage (http://www.protectnz.org.nz/grids/index.asp?id=12&area=12) provides an excellent national model

2. Principles for Conserving Agricultural Ecosystem Services

Agricultural systems have the potential to improve the environment, to be the custodians of critical aspects of farm genetic diversity needed for future agricultural improvement programs around the world, and to host vast populations of wild biodiversity. Yet our production systems have not been developed to do so, in recent history. While modern agriculture has brought vast increases in productivity to the world's farming systems, it is widely recognised that much of this may have come at the price of sustainability. The bountiful yields of modern agriculture have been "purchased" with high levels of nonrenewable and often toxic inputs such as fossil fuels, inorganic fertilisers, pesticides and herbicides. In developing countries, these inputs are often imported and strain the importing country's balance of payments. Often, purchased inputs are used primarily on export crops, and do not improve local food security.

How does this relate to biodiversity? We know that conventional agricultural practices displace nature. Instead of letting the ecosystem control itself, control comes from outside. Industrially-produced fertiliser substitutes for relationships between plants and nitrogen-fixing bacteria, overriding rather than working with agroecosystems. Pesticides and insecticides replace equilibrating mechanisms such as pest and insect predators. But it is equally possible to reverse this approach, to find the ways and means to restore and build on the resilience and strength of the agroecosystem in the struggle to fight pests, diseases or soil deficiencies, or to augment crop yields through pollination. The component of agrobiodiversity which we call "agricultural ecosystem services" is a potent tool to be encouraged and fostered. Agrobiodiversity can be used to reestablish natural balances in farming systems with healthier environments, a more rational use of resources, and a greater dependence on internal rather than purchased controls. And to do this, the primary technique is "biodiversification" of agroecosystems, to evoke self-regulation and sustainability.

Key prinicples for the conservation of agricultural ecosystem services are:

2.1 It is important that everyone- farmers and policymakers both- understand the concept that agricultural ecosystem services can sustain themselves with proper design.

2.2 Ecosystem services have the potential to reduce both off-site inputs and on- and off-site pollution.

2.3 Promoting identification and taxonomy is necessary.

2.4 Assessment of risks over time, relative dependence, and sustainable livelihoods are critical issues for agricultural biodiversity, and need to be in appropriate balance.

2.5. Policy makers are biased toward large scale plans, whereas much of agrobiodiversity is fine-scaled.

2.6 Costs and benefits of agrobiodiversity goods and services need to be identified.

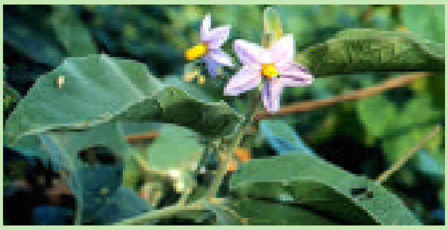
2.7 Costs and benefits need to be distributed on the basis of careful assessment of possible trade-offs, paying attention to incentives and subsidies, and making them appropriate.

2.8 Creating popular awareness and education is necessary for change

2.9 It is necessary to enhance capacity for adaptation to change.

Principle 2.1. It is important that everyone- farmers and policymakers both- understand the concept that agricultural ecosystem services can sustain themselves with proper design.

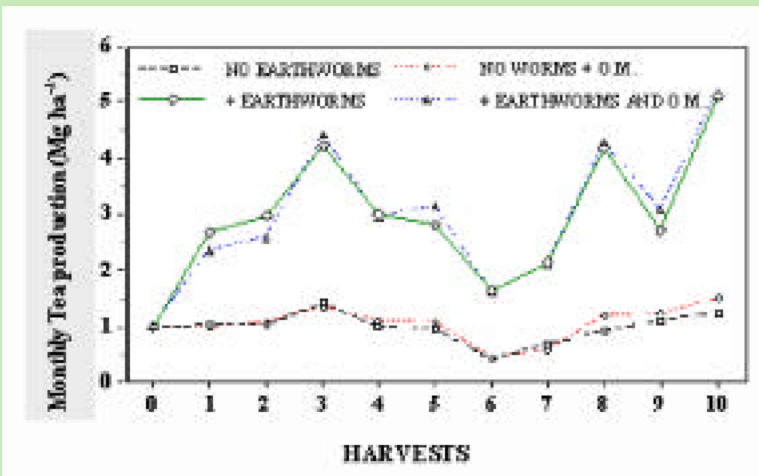
This principle is a key concept behind the notion of ecosystem services, and needs to be understood thoroughly: we often take ecosystem services for granted, as they are provided



Pollination Services in **Kenyan** Horticultural Crops:
In a forested landscape under development for horticultural crops in Kenya, it has been shown that the production of eggplant is entirely dependent on native bee pollinators. Not just any pollinator will do, as eggplant can only be properly pollinated by certain bees which "buzz pollinate" - that is, know how to bite the flower and vibrate their wing muscles at a certain frequency, such that pollen comes flying out of small pores in the flower, and can be carried to another flower to produce fruit. Without this "ecosystem service" , no fruit will be produced. Honeybees cannot buzz pollinate, but it has been shown that two species of solitary bees, which occur naturally in the forest that is being cleared for farms, are very effective pollinators. The bees only get pollen from eggplant, as it does not produce nectar. Thus they cannot live exclusively on agricultural land, and make use of different resources along farm paths, and in the plots of forest that have not yet been cleared. In the dry season, they depend more heavily upon the wild ecosystem for floral resources. Farmers have recognized the importance of this "pollination service" in leaving tracts of forest standing.

from Gemmill and Ochieng 2000

Soil Biodiversity Services in Tea Gardens in **India**:
Long-term exploitation of soil under tea gardens has led to stagnation in yields and quality, as well aswith significant changes in soil physical, chemical and biological conditions including decreasing organic matter content, cation exchange and water-holding capacity. The diversity and abundance of soil biota has also declined. A patented technology entitled "Fertilisation Bio-Organique dans les Plantations Arborées" (FBO) has been developed and tested which improves the physical, chemical and biological soil conditions by inoculating a mixture of low and high quality organic materials (tea prunings and manure) and earthworms into trenches dug between the rows of tea plants. Measurements performed at two sites, beginning in 1994, (see graph) have shown that this technique is much more effective than 100% organic or 100% inorganic fertilisation alone, increasing yields on average by up to 276% and profits by an equal percentage (from around US$2,000 ha^{-1} using conventional techniques to about US$7,600 ha^{-1} in the first year of application. This technique has been extended to other countries and is now being used in over 80 ha. Over 20 million earthworms are being produced each year.



from: http://www.fao.org/landandwater/agll/soilbiod/highligh.htm#macro

Natural Pest Control, Using Biodiversity that Mitigates Pests and Diseases in Maize in **Africa**:

The International Centre of Insect Physiology and Ecology (ICIPE) based in Nairobi, Kenya, is identifying ways to use natural, long-evolved defenses between grasses and their enemies (plant pests) to good use to control stemborers, the major pests of maize in eastern and southern Africa. Losses to stemborers can reach as high as 80% in some areas, and average about 15-40%. Spraying with pesticides is not only expensive and harmful to the environment, but is usually ineffective, as the chemicals cannot reach the pests deep inside the stem. Preventing crop losses from stemborers could increase maize harvests enough to feed an additional 27 million people in the region. Called the "push-pull" strategy, ICIPE'S approach relies on a carefully selected combination of companion crops planted around and among the maize plants. Native and other forage grasses are planted in a border around the maize fields, where invading adult moths become attracted to chemicals emitted by the grasses themselves. Instead of landing on the maize, the insects head for the bordering grasses, forming the "pull" part of the strategy. One of the grasses has its own means of defending itself against the pest, by secreting a sticky substance that traps the insects. The "push" part of the scheme is provided by intercropping plants which repel insects, in the maize field. Fortunately, one plant which repels maize pests, *Desmodium,* is a legume which also enriches the soil and reduces the growth of a parastic weed, *Striga*. Farmers practicing "push-pull" can harvest three crops, maize, *Desmodium (*as animal feed), and forage grasses. Maize production on 150 farms practising "push-pull" in Kenya is up by 25-30% and milk production has increased by an average of 50-60% among participating farmers in Kenya's Suba District, with the benefit-to-cost ratio estimated at 2.25 among farmers using the push-pull approach.

from Khan and Mengech 2001

essentially for "free", so long as we do not abuse the ecosystem. When we lose them, however, we end up paying mightily, for soil fertility amendments, pest control services, and pollination services. It may be helpful to give illustrations of how ecosystem services function, so that we can look at what our policies and plans are ultimately aiming at. Let us consider some illustrations of each of the three main agricultural ecosystem services: pollination, soil biodiversity, and biodiversity that mitigates pests and diseases (see boxes). In addition, we will present below three much-appreviated reviews of the scientific understanding behind each agricultural ecosystem service.

Natural pest control as an ecosystem service:

An estimated 99 percent of potential crop pests are controlled by natural enemies, including many birds, spiders, parasitic wasps and flies, lady bugs, fungi, viral diseases, and numerous other types of organisms (DeBach 1974). These natural biological control agents save farmers billions of dollars annually by protecting crops and reducing the need for chemical control (Naylor and Ehrlich 1997). Scientists have tried to then identify what it is, in an agricultural system, that encourages natural biological control agents. A review of 150 published papers on biodiversity effects on pest occurance (Risch ***et al***. 1983) found that in 53% of the cases plant pest density was decreased in diversified systems, in 18% pest density increased, in 20% a varied response was observed, and no change was observed in 8% of the analysed cases. The mitigating effect of biodiversity appeared to be caused by herbivore response to diversification rather than by enhanced natural enemy activity. While the exact ecological mechanism that determines the effects of agricultural diversification on pests is still not clear, many applied ecologists have turned their attention to plant diversification in their attempt to increase biodiversity and decrease pest impact (Altieri ***et al***, 1991). As stressed in a Swiss strategic planning document, (Anonym, 1989) an increase in plant biodiversity is accompanied by an increase in the biodiversity of other taxa such as arthropods. Moreover, maintaining biodiversity is important because we cannot always identify which species are critical, or which species are important in the future (Burton ***et al***., 1992).

Soil biodiversity as an ecosystem service

Soil organisms play a central role in the decomposition of dead organic matter and wastes, and this decomposition process also renders harmless many potential human pathogens. People generate a tremendous amount of waste, including household garbage, industrial waste, crop and forestry residues, and sewage from their own populations and their billions of domesticated animals. A rough approximation of the amount of dead organic matter and waste (mostly agricultural residues) processed each year is 130 billion metric tons, about 30 percent of which is associated with human activities (derived from Vitousek et al. 1986). Fortunately, there is a wide array of decomposing organisms-ranging from vultures to tiny bacteria-that extract energy from the large, complex organic molecules found in many types of waste. Like assembly-line workers, diverse microbial species process the particular compounds whose chemical bonds they can cleave and pass along to other species the end products of their specialised reactions. Many industrial wastes, including soaps, detergents, pesticides, oil, acids, and paper, are detoxified and decomposed by organisms in natural ecosystems if the concentration of waste does not exceed the system's capacity to transform it.

In agricultural systems, it is important to make efforts to keep a viable component of soil biota, as many of the changes that people impose on soils when they farm are not advantageous to soil organims. It has been well documented, that the conversion of natural vegetation to other land-uses, including agriculture, results in change in the diversity of the soil community. As land conversion and agricultural intensification occur, the ***planned*** biodiversity above-ground is reduced (up to the extreme of monocultures) with the intention of increasing the economic efficiency of the system. This impacts the ***associated*** biodiversity of the ecosystem – micro-organisms and invertebrate animals both above and below ground - lowering the biological capacity of the ecosystem for self-regulation and thence leading to further need for substitution of biological functions with agrochemical and petro-energy inputs. We know that soils change under agriculture, but we do not know the critical point at which biological processes cease to dominate, and purchased inputs must compensate. The detection of critical thresholds for functional change is however still a matter of debate. The high biodiversity within many functional groups has been interpreted as conveying a substantial degree of redundancy to the soil biota and led to suggestions of high resilience (Swift et al., 1996; Lavelle et al., 1997; Giller et al., 1997).

There are a wide range of ‘soil bio-technologies’ that have the potential to increase and sustain productivity that are currently under-utilised because of the lack of critical evaluation for application to small-scale agriculture. The soil biota may be manipulated by both direct and indirect means. ***Direct*** management includes inoculation with species of soil biota, including nitrogen-fixing bacteria, mycorrhizal fungi, control agents for pest and diseases and beneficial macrofauna such as earthworms. Modern molecular research is also increasing the potential for genetic manipulation of some of these organisms prior to inoculation. ***Indirect*** management is achieved through manipulation of the living plant and cropping system, organic matter of differing resource quality, other soil amendments and soil tillage.

Pollination as an ecosystem service

One third of human food is derived from plants pollinated by wild pollinators. Without natural pollination services, yields of important crops would decline precipitously and many wild plant species would become extinct. In the United States alone, the agricultural value of wild, native pollinators - those sustained by natural habitats adjacent to farmlands - is estimated in the billions of dollars per year. As many agricultural landscapes across Europe and North America have become uniform over vast areas, traditional nesting sites for pollinators on farms, such as hedgerows, field margins and other "waste places" have been eliminated. Pollination services provided to crops under modern agriculture have declined precipitously, and there is a recognised need to conserve these services.

TOOLS

- The definitive volume on ecosystems services is the following book, with chapters on soil, pollinators, and natural pest control, among others:
  Dailey, G. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Covelo, CA. 392 pp.
- A subsequent review article in Nature is widely cited: Robert Costanza et al., "The Value of the World's Ecosystem Services and Natural Capital," Nature, Vol. 387 (1997), p. 259.

Principle 2.2 Ecosystem services have the potential to reduce both off-site inputs and on and off-site pollution.

In all agroecoystems, the cycles of land, air, water, and wastes have become "open": meaning farm productivity depends on inputs acquired from off the farm, and produces outputs that are not recycled but need to be disposed of. This is true of all modern agriculture, but it occurs to a larger degree in industrialised commercial monocultures than in diversified small-scall farming systems dependent on human/animal power and local resources. The modern farming systems that are replacing traditional practices around the world and achieving high levels of productivity by "controlling" the environment butthese modern systems require large amounts of imported energy to accomplish the work usually done by ecological processes in less disturbed systems. Agricultural research and development is at a new turning point now, to find ways to reduce the wasteful resource use patterns of modern agriculture, and eliminate its detrimental impact on the environment by harnessing ecological services.

The search for self-sustaining, low-input, diversified and energy-efficient agricultural systems is now a major concern of some researchers, farmers, and policymakers worldwide. Key strategies for low-input sustainable agriculture are primarily achieved through the overall design of the farming system to promote fundamental ecosystem services. From a management viewpoint, the basic components of a sustainable agroecosystem which will enhance these functions include the following:

BEST PRACTICES

- Using vegetative cover as an effective soil and water-conserving measure, met through the use of no-till practices, mulch farming, use of legume cover crops, green manures, and so forth.
- Returns of farmyard manures and household wastes, with or without composting;
- Integrated Soil Fertility Management (ISFM) ie the judicious use of both organic and inorganic sources of nutrients rather than either alone;
- Using nutrient recycling mechanisms throught the use of crop rotations, crop/livestock mixed systems, agroforestry and intercropping systems based on legumes, and so forth.
- The use of conservation tillage rather than continuous deep ploughing;
- Choice of crops and associated plants which have high nutrient use efficiency.
- Natural pest regulation enhanced through biodiversity manipulations.
- Considering the resource needs of pollinators, on the farm.
- Promoting a diversified farm landscape, including crop rotations and intercropping within the fields, but also diversification on the edges and outside of the farm, for example, in crop-field boundaries with windbreaks, shelterbelts, and living fences, which can improve habitat for wildlife and beneficial insects, provide sources of wood, organic matter, resources for pollinating bees, and in addition, modify wind speed and the microclimate.

The basic concepts of a low- external input sustainable and diverse agricultural systems must be synthesised into practical alternative systems to suit the specific needs of farming communities in different agroecological regions of the world.

One way of promoting sustainable agriculture is to simply improve farm management. Well-managed farming systems nearly always use less synthetic chemical pesticides, fertilisers and antibiotics per unit of production than comparable, but less well-managed farms. Reduced use of these inputs lowers production costs and lessens agricultures's potential for adverse environmental and health effects without necessarily decreasing, and in some cases increasing, per-acre crop yields and the productivity of livestock management systems (NRC report on alternative agriculture).

Another approach to sustainable agriculture is to aim for a common standard that incorporates all of the above practices; the most viable of these is the organic farming movement. Organic farming is a production system that sustains agricultural production by avoiding or largely excluding synthetic fertilizers and pesticides. Whenever possible, external resources, such as commercially purchased chemicals and fuels are replaced by resources found on or near the farm. Whether certified or not, or wholly organic or not, farming systems that aim for the standards of organic farming are learning to depend on ecosystem services. However, it should also be noted that lower-input farming practices of organic agriculture typically require more information, trained labor, time and management skills per unit of production than conventional farming. Thus, extension services and farmer-to-farmer sharing of information is of major importance.

TOOLS

- Farmer-to-farmer exchanges, such as the farmer field schools employed in Indonesia, as described in Roling and van de Fliert (1998), have been very effective in facilitating the sharing of information among farmers. .
  see also documents available for download, at: http://www.communityipm.org/downloads.html
- NGOs have had a large role to play in the spread of alternative agriculture practices. The SANE program aims to enhance capacity building and human resource development in the area of sustainable agriculture through agroecological training,

participatory research, policy advocacy and information networking among no-governmental organisations and other national/international organisations in Africa, Asia and Latin America.
http://nature.berkeley.edu/~agroeco3/sane/index.html

- Sustainable agriculture extension programs; the International Service for National Agricultural Research offers a number of resources for strengthening both research and extension: http://www.cgiar.org/isnar/
- LEISA: There are numerous NGOs and community groups networked through the Dutch-based Centre for Information on Low External Input and Sustainable Agriculture (ILEIA). This organization, founded in 1984, was a response to concern that 'mainstream' agricultural development was by-passing the small farmers of the South. ILEIA started to identify promising technologies involving only marginal external inputs, and building on local knowledge and traditional technologies, involving the farmers themselves in development. It produces the quarterly LEISA Magazine , in which a large number of local initiatives is given publicity. While management of biodiversity is not the primary aim, promotion of biodiverse agriculture is a central part of ILEIA's activities.
  http://www.ileia.org; publication of a journal four times a year. Local organisations and individuals in the South can receive this publication free of charge on request. To subscribe, write to ILEIA or send an e-mail to: subscriptions@ileia.nl.
- IFOAM, the International Federation of Organic Agriculture Movements, represents the worldwide movement of organic agriculture and provide a platform for global exchange and cooperation.. IFOAM is committed to a holistic approach in the development of organic farming systems including maintenance of a sustainable environment and respect for the need of humanity. The federation's main function is coordinating the network of the organic movement around the world.
  http://www.ifoam.org/

Principle 2.3 Identification and taxonomy is essential for supporting agricultural ecosystem services.

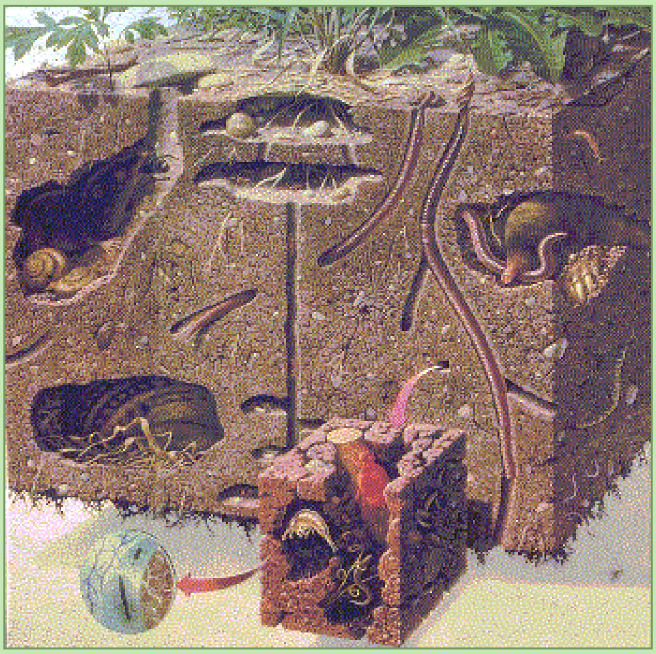
In many areas of biological diversity, there is a need for greater species identification and taxonomy. But nowhere is the need greater than for those organisms involved in agricultural ecosystem services: pollinating insects, soil fauna, and biodiversity involved in pest regulation. These are the "little things that run the world": insects, for example are far more numerous than any other taxa on earth.

Having the correct identification name gives access to correct and relevant information, a wrong name leads to false and irrelevant information. Taxonomy is that branch of science dedicated to discovering, identifying, naming and classifying organisms (species) and understanding their relationships. It provides an information system based on these relationships and is the foundation of all biological science. It allows us to distinguish individual species from amongst the millions with which we share this planet, and to understand their place, role and functions within living systems.

The state of knowledge of smalll organisms, such as insects and microbia that figure so prominently in ecosystem services, is still very rudimentary. Yet taxonomists are themselves an endangered species. For example, the following information has been compiled on the number of practising bee taxonomists associated with major institutions by country or region, as of 1999:

Let us take **soil organisms** as an example, although the same problems and similar solutions may apply to other functional groups. The soil biota constitutes a major fraction of global terrestrial biodiversity. The majority of the terrestrial phyla of invertebrates, protists, fungi and bacteria are represented in the soil community. Within each of these groups the species diversity may also be extremely high. The different groups require different methods for their extraction from soil, identification and quantification. The necessity for using a variety of methods, many of which are destructive to the soil habitat means that there is no single case where a full inventory of the soil diversity has been achieved. For some groups the methods have significant limitations and the percentage recovery of even the highest estimates may be low. This is particularly so for the micro-organisms. Traditional methods relied on the use of agar growth media to isolate fungi and bacteria but it is recognised that this is highly selective and results in only a small fraction of the diversity being recognised. Hawksworth (1999) estimated that less than 1% of fungi were identified with these methods. Molecular methods have given much greater insights. Torsvik et al (1994) demonstrated the existence of 13,000 genetically distinct bacterial types in a small sample of soil compared with only 66 isolated by the conventional plating techniques.

More efficient inventory is possible for the invertebrates, but levels of diversity are still very high. Over 1000 species of invertebrates were identified in 1m2 of soil in temperate forests in Germany (Schaefer and Schauermann, 1990).



from the Soil Biodiversity Portal- see tools

Because of the very demanding nature of soil biota inventories, the practice of using 'Key Functional Groups' has become more common (see Box, below). This approach economises on expertise, time and cost by obviating the necessity of attempting to assess all groups. There is as yet no general agreement on the number of groups to be used or on their definition but three broad criteria can be applied. The first is that of distinct functional identity, ie. that the different groups have distinct and clearly definable functions within the ecosystem. Some of these functions are very specific, such as nitrogen fixation, whilst others are more general, such as soil structure modification. Second the set should embrace a wide range of taxonomic groups. Third the characterisation of the group in terms of identity and abundance should be relatively easy.

One possible list of Key Functional Groups of the soil biota which fulfill these criteria:

Ecosystem Engineers (eg. macrofauna such as termites and earthworms
Microregulators (eg. microfauna such as nematodes)
Micro-symbionts (eg. mycorrhizal fungi, rhizobia)
Soil-borne pests and diseases (eg. fungal pathogens, invertebrate pests)
Carbon and Nutrient transformers (eg. methanogenic and nitrifying bacteria)
Decomposers (eg. cellulose degrading fungi or bacteria)

USA [1]	Mexico	Brazil [2]	Europe[3]	Africa	China	Japan	Australia
10	1	6	3	2	1	2	3

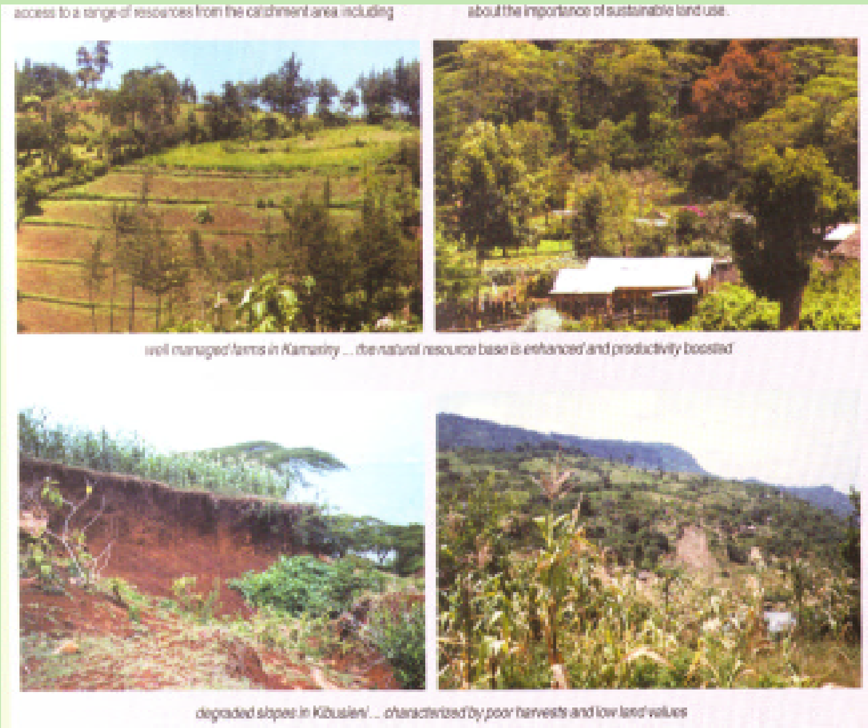
[1] includes 7 workers officially retired, but still active
[2] includes 2 workers officially retired, but still active
[3] includes 1 worker officially retired, but still active
source: Dias, Raw and Imperatri –Fonseca, 1999

As can be seen, young taxonomists are not replacing older and retiring specialists. New techniques are desperately needed to make taxonomomic tools that can be used by non-specialists.

However, there are a number of attempts to make the indentification process which is so critical to soil biota, pollination conservation and natural pest control easier for non-specialists to use (see box, soil organisms). A large intergovernmental initiative, BIONET, has been set up for taxonomic capacity buidling in developing countries, which seeks to link experts and needs around the world, particularly for agriculture- related taxonomic identifications. Ways of training parataxonomists have been explored for pollinating bees; a simplified key to the genera of bees of North and Central America has been developed in English and Spanish (Michener, McGinley and Danforth 1994), and three 10-day sessions of the "Bee Course" have been held in the southwestern US, bringing together an international group of pollination biologists and field scientists with experienced bee taxonomists.

TOOLS

- Soil Biodiversity Portal:
  This website, maintained by UN FAO, provides general conceptions on the meaning and significance of soil biodiversity, stressing the need for integrated biological soil management. It also provides a framework under which soil biodiversity can be assessed, managed and conserved.
  http://www.fao.org/landandwater/agll/soilbiod/default.htm
- BioNET-INTERNATIONAL, the Global Network for Taxonomy, is an inter-governmental initiative for taxonomic capacity building in developing countries. BioNET-INTERNATIONAL is dedicated to supporting regional and national poverty eradication programmes via sustainable use of natural resources, agricultural development, and conservation of biodiversity by enabling developing countries to achieve realistic self-reliance in the skills of identifying and understanding the relationships of the different organisms which constitute our living environment. It is comprised of sub-regional LOOPs (Locally Organised and Operated Partnerships) of developing country institutions, supported by a consortium of developed country institutions (BIOCON), and a Technical Secretariat (TecSec).
  http://www.bionet-intl.org/
- The presence of key groups of natural enemies may be used as indicator when it is not possible to identify every component species. The monitoring of natural enemy effects via antagonist-prey ratios has been proven to be very effective (Nyrop & van der Werf, 1994).
- Information about the Bee Course can be obtained by contacting:
  Dr. J. Rosen, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192, USA
- Michener, C.D., R.J. McGinley and B.N. Danforth. 1994. The Bee Genera of North and Central America (Hymenoptera: Apoidea). Smithsonian Institution Press, Washington, D.C.



In two sub-locations of Keiyo District in **Kenya**, two micro-catchments that are virtually identical in terms of ecology stand in stark contrast - the result of actions taken, or not taken, by local groups. A cost benefit analysis carried out on Kamariny and Kisbusieni micro-catchments found that one group of farmers is reaping the benefits of their investment in soil conservation, while the other is wallowing in all the classic symptoms of land degradation.

Kamariny and Kibusieni are both situated on the escarpment in Keiyo district, with similar soil types, elevation and vulnerability to erosion. Over the years the 28 households of the Kamariny microcatchment (total of 50 acres) have invested heavily in planting treees, building stone walled terraces and planting napier grass to prevent erosion. They spend an equivalent of Ksh 17,000 (more than $200) per household in cash and labour on soil conservation measures. The 45 households in the more densely populated Kibusieni micro catchment spend an average of only Ksh. 1,400 (less than $20) each on soil conservation measures each year.

The benefits to the people in Kamariny are many. They have access to a range of resources from the catchment area including vegetables, honey, medicinal plants, wild fruits and adequate water from the springs. Most of these are no longer available in Kibusieni and households have to source them from further afield. The dividends in terms of farm output are also clear. In Kibusieni, farmers experience poor yields, with a minimum yield 8 times less than in Kamariny. Furthermore the output of maize in Kamariny has been increasing steadily over the years, while it has been on the decline in Kibusieni. The mean worth of an acre of land in Kamariny is about Ksh 75,893 (about $1,000) while in Kibusieni it is only 46,756 (about $625). Thus environmental conservation has a strong positive influence on the land productivity and its value in general.

The study underlines the role of community initiative in bringing about positive changes in community based natural resource management, and that investing in land can yield high dividends. Conversely, it also confirms that external support can do little if local people are not themselves ready for change (both communities received development support in the past). Such experiences will be crucial in raising awareness among local communities about the importance of sustainable land use.

from SARDEP 1999-2001 MidTerm Progress Report

Principle 2.4 Appreciate that while policy makers are biased toward large – scale plans, much of agrobiodiversity is fine-scaled.

As we seek to develop more ecologically-based agricultural development programmes, new understandings and capacities will need to be built among agricultural policy makers, the agricultural research community, and farmers. Modern agricultural research has sought to find technological packages that can be applied across a wide range of heterogeneous agricultural environments and circumstances, usually by making the environment more uniform, with irrigation and agricultural inputs. The challenge now is to find more site-specific ways of managing agricultural lands. Cropping systems and techniques tailored to specific agroecosystems result in a more fine-grained agriculture, based on appropriate traditional and improved genetic varieties and local input and techniques, with each combination fitting a particular ecological, social and economic niche. The participation of farmers, who have this intimate knowledge of the lands they manage, becomes of even greater importance (see box, left).

For the key functional groups providing agricultural ecosystem services (pollinators, soil biota, natural enemies of agricultural pests) we do know of a number of best practices for promoting their persistence in an agricultural landscape. How to translate this into agricultural policy will need the concerted attention of national agricultural planners and policy makers, in dialogue with biodiversity planners.

We know that following the set of best practices below will promote the ecosystem services to be provided by pollinators, nutrient recyclers, and natural enemies of crop pests. Few farmers will have the time or resources to address each “Best Practice” in turn, but many of them are subsumed under general land conservation activities. With a small investment in further public education, farmers who are already inclined toward good land stewardship may learn to watch out for the small resource areas or special considerations that beneficial farm biota require. With more emphasis on farmers’ learning structures (section 3.5), farmers can learn from each other.

BEST PRACTICES

- Promote diverse landscapes and spatial differentiation
- Leave wild strips
- Reduce applications of pesticides
- Conserve resources for pollinators
- Exploit areas differently or rotate.
- Use additives that enrich the soil further
- Use less machinery
- Reintroduce/inoculate soil beneficial organisms
- Recycle organic waste
- Promote habitats on-farm that reduce pests and increase natural enemies
- Practice soil conservation measures

Diversity of land use can be attained by a variety of methods. They include crop rotations, adapting choice of crops and cultural methods to soil and soil moisture conditions, interplanting crops in a mixture (polyculture), or planting crops among useful trees either conserved in land preparation or deliberately planted (agroforestry). There are also various mixed farming systems in which arable, trees and livestock are integrated. The values of maintaining landscape level diversity in any of these ways include maximizing the use of land, managing pests and diseases, sustaining habitats for pollinators and other useful biota, and enhancing biodiversity in the soil, as well as sustaining both floral and faunal diversity. It should be kept in mind that it is much more common to adopt different management methods on different micro-environments on small farms. Land tenure issues and policies to promote this kind of site-specific management are discussed in section 3.3.

Principle 2.5 Assessment of risks over time and relative dependence are critical issues for both national agricultural policy and biodiversity strategies.

The objectives of ecosystem management are the optimisation of sustainability, the minimisation of risks and the maximisation of ecosystem services. National planners must carefully address the issue of minimising risks, for the sustainable livelihoods of their citizens. In relation to agriculture, many of the inherent risks relate to decisions on appropriate agricultural yields, and how to obtain those yields. A national agricultural policy on sustainable agriculture includes, whether implicitly or explicitly, the yield expectations of the country; a farmer's approach to production also includes a yield expectation. If it is expected that yields must be high, a high level of risk must be expected. Other systems tolerate lower yields and lower risks. This is a matter of societal choice, as well as ecological factors.

One aspect of high risks is a heavy dependence on outside sources of material or technology. A transition to more sustainable agriculture has added benefits, in terms of minimising risks, in that the farming system becomes more "closed", using internal inputs and ecosystem services rather than outside, purchased inputs.

The model of Cuba, as it made a rapid nationwide conversion to organic agriculture, is a

Since **Cuba**'s trade relations with the Eastern bloc fell in 1990, pesticide imports dropped by more than 60%, fertilizers by 77%, and petroleum for agriculture dropped by 50%. Suddenly, an agricultural system almost as modern and industrialized as that of California was faced with a tremendous challenge: the need to double food production and reduce inputs by half and at the same time maintain export crop production so as not to further erode the country's desperate foreign exchange position.

Since 1989, the Cuban government has adopted a policy to promote a new science of agriculture more in tune with the scarce resources and the need for food self-sufficiency. Cuba's new research directions heavily emphasise understanding and exploiting the subtle yet powerful abilities of biological organisms to perform many of the tasks previously done by synthetic chemicals. Biologically based or derived fertilisers and biological control of pests are at the heart of this new quest for biologically sophisticated management of agroecosystems.

The policy objectives during this special period, to achieve a low petro-chemical input sustainable agriculture without reducing yields, have required a major reorganisation in the structure of agricultural research and extension in Cuba and the flow of information. The de-emphasis of capital- and energy-intensive technologies requires new relationships between scientists, extension agents, and farmers. The pre-existing role of scientists as generators of innovative technological packages and of extension agents as conduits of their delivery to farmers is clearly changing in favor of a new partnership between the three in the development and dissemination of new agricultural approaches.

good object lesson not only in the efforts needed, but also the benefits possible by such a transition. (see box).

Principle 2.6 Costs and benefits of agrobiodiversity goods and services need to be identified and distributed on the basis of careful assessment of possible trade-offs, paying attention to incentives and subsidies, and making them appropriate.

We do not yet have a well-developed analysis of the costs and benefits of ecosystem services. Some review articles and widely cited texts have given very impressive figures for the valuation of ecosystem services, yet few of these values are yet reflected in conventional economic accounting systems. To get these services properly entered into national economic accounting, we need to have highly realistic, well documented analyses of costs and benefits.

Cuban scientists have become increasingly reliant on farmer innovation and experimentation for research directions that complement their efforts to develop promising organic farming practices as well as to adapt techniques developed outside the country. They are emphasizing technologies recovered or developed at the local

level that have widespread applicability, which extension agents and scientists disseminate over a broader region, and low-input technologies utilized in other countries, which are promoted for local experimentation and adoption.

One of the keys to Cuba's new model of agriculture is to find ways to reduce chemical use fo management of plant disease, insect pests, and weeds. The most interesting aspect of contemporary insect pest management efforts in Cuba are the Centers for the Production of Entomophages and Entomopathogens (CREEs) where decentalised, "artesanal" production of biocontrol agents take place. Despite limited resources, the government has invested its capital in construction and operation of these centers. By the end of 1992, 218 CREEs had been built throughout Cuba to provide services to state, cooperative and private farmers.

The centers produce a number of entomopathogens (*Bacillus thuringiensis, Beauvaria bassiana, Metarhizium anisopliae,* and *Verticillium lecani*), as well as one or more species of Trichogramma, depending on the crops grown in each area. CREEs are maintained and operated by local technicians.
Cuban scientists are also pursuing several other lines of research in developing alternatives to conventional insecticides, including work on parasitic nematodes and plant-derived pesticides. A program to develop reliable and cost-effective methods for the production and field application of several species of nematodes that attack insects is currently under way; however, mass production is still in the developmental stages.

Scientists are also screening a large number of plants for insecticidal, fungicidal, bactericidal and herbicidal qualities. In addition to these screening effors, applied work has been initiated on the cultivation and production of two species of plants with known insecticidal qualities, neem and Melia. Small plantations of neem and Melia have been started and research on formulations and application methods is advancing.

from Altieri

Examples of negative side effects of pesticide use

* estimated 1 million pesticide poisoning cases per year
* ca. 20,000 deaths per year
* chronic health effects
* pollution of drinking water
* pesticide residues in food
* damage to beneficial insects and the natural environment
* lack of sustainability in agricultural production

Policy factors which may contribute to excessive use of pesticides:

Price Factors

Government sells pesticides below market price or distributes them free of charge

Donors provide pesticides at low or no costs

Government subsidises pesticide companies

Subsidized credit for pesticide use

Preferential rates for import duties, taxes and exchange rates

Plant protection service outbreak budget

Non Price Factors

Misguided use of governments' activities in reducing pesticide damage
Governments' investment in pesticide research

Inadequate government research in environmentally benign pest management

Lack of adequate procedures for pest and crop loss definition

Lack of information on non-chemical measures

Lack of transparency in regulatory decision making

Lack of internalization of pesticide production and use externalities

source: GTZ Pesticide Policy Project

Thus, the essential BEST PRACTICES with respect to each agricultural ecosystem service, are:

Pollinators

Assess the economic contribution to yield/opportunity cost of altering habitat.
Assess the economic contribution of pollinators to conserving the genetic diversity of crops.
Review the system of economic instruments that affects the distribution of costs and benefits of pollination services.
Create a market for pollination services based on ecosystem management principles.

Soil Bio-Diversity

- Assess the economic contribution of soil biodiversity at various scales with linkage to potential funding mechanisms at watershed, national and global scales.
- Assess the benefits and costs of integrated soil management versus conventional practices at farm and watershed level.
- Review the system of economic instruments that affects the distribution of costs and benefits of pollination services.
- Develop support for organic and biodiversity-friendly farming by small holders.
- Assess the new market for greenhouse gases (CH_4, CO_2, NO_x, SO_2), mitigation, water quality enhancement, etc. provided through soil biodiversity conservation.

Pests

- Assess the benefits and costs of mitigation strategies involving crop management practices, habitat boundaries and IPM.
- Develop support for organic and biodiversity-friendly farming by small holders.

Even in the absence of detailed valuations of agricultural ecosystem services, there are many initivatives underway to develop markets for organic agriculture, which includes the promotion of most agricultural ecosystem services. GTZ, for example, supports several programmes that seek to build such markets. One of the these, Protrade, encourages public-private-partnerships. Specialising in trade and business promotion, the program offers assistance in sector-related marketing, product and production consulting in more than 90 countries, promotion in Germany and the EU, trade fair assistance and a comprehensive information service. Protrade included an organic products sector in 1993 in reaction to the growing demand for biological cultivation of products and the strong interest of many third world countries in organic agriculture and farming (Thies 2000). The main emphasis of the work in the organic products sector is on developing new trade contacts, consulting in the areas of organic farming, certification, product development, management and quality assurance, as well as offering support for participation and international specialist trade fairs. Fifteen countries are currently in the consulting programme: the Dominican Republic, Ecuador, Haiti, Honduras, Kenya, Madagascar, Mexico, Nicaragua, Peru, Russia, Senegal, Zimbabwe, Uruguay and Tanzania.

One key element of building markets, and assuring that farmers receive sufficient incentives for conserving agricultural biodiversity, is to develop certification systems that guarantee organic products for consumers, and higher prices for producers. TransFair is a seal offered by the labeling initiative “Transfair International” to traders who buy from registered cooperatives in developing countries and abide by fair trade criteria. Products covered by the TransFair seal include coffee, honey, cocoa, sugar and tea. Several other initiatives like TransFair are all grouped in the Fair Trade Federation. They, and other important actors in the field of labeling organic products can be found on the websites given in Tools, below.

Along with building proper incentive measures, it is important to eliminate pervese subsidies, of which there are many in the agriculture sector. There is a growing recognition that currently most if not all policy measures used to support agriculture act as powerful disincentives against sustainable agriculture, especially with respect to subsidies for agricultural inputs. Countries have adopted these policies because they believe that the economic benefits outweigh public expenditure. But in fact, recent research shows that the use of chemical pesticides has been promoted and subsidised by governments even though there has been little information on the net benefits of a dependency on pesticide usage compared to other crop protection strategies (GTZ Pesticide Policy Project, no date). AGENDA 21 of the United Nations Conference on Environment and Development in 1992 demands the implementation of integrated pest management (IPM) as an alternative to dependency on unilateral use of agricultural chemicals. This concept stresses the use of local knowledge and aims at improving the decision making capacity of farmers instead of disseminating fixed packages of external technology.

But the paradigm switch that is indispensable for the dissemination of IPM will not be obtained without a change in the general institutional framework of economic incentives that govern crop protection. In many instances, national governments hesitate to implement the necessary political changes (see box, Policy Factors). They lack adequate concepts for policy analysis in a sub-sector that is dominated by specialists in natural science and toxicology. Agricultural interest groups fear that policy reform measures aimed at a reduction of chemical pesticides will threaten their competitiveness in global agricultural product markets.

The economic justification of pesticide use in world agriculture and horticulture is often doubtful. Negative side effects occur in many instances but are not accounted for as costs (see box, Negative Side Effects of Pesticide Use). For example, farmers do not consider occupational health costs in their decision to use pesticides. The costs of the damage of the natural environment are born by the society as a whole and only perceived in the long run. They are not embodied in the private costs of pesticide application. Therefore, actual pesticide use often exceeds the social optimum.

There are a number of new resources and initiatives being launched to assist countries to better examine existing policy decisions, and undertake a reform of crop protection policy instruments within government, and private sector approaches (see tools).

TOOLS

- Organisations promoting trade and labelling programs to provide more resources to farmers practicing "green agriculture" include:
  http://fairtradefederation.com
  http:// green-trade.de
  http://www.ifoam.com

- The World Organic Commodity Exchange (WOCS, www.wocx.net) represents over 2500 organic products, including textiles, furniture, cosmetics, wine, vegetables, fruits, dog food, baby food, ice cream and water.

- The pilot project 'Reform of Crop Protection Policy as part of an Agri-Environmental Policy Framework' was initiated by the GTZ (German Technical Cooperation) Department for Rural Development. It aims at developing and testing methodologies and instruments for crop protection policy reform.

  The project focuses on developing and testing instruments for economic policy analysis and tools for policy reform, establishing methodologies for evaluating the impacts of knowledge-based technologies in crop protection, and ensuring sustainability through capacity building and regional networks of local experts in policy analysis

- The book "Bugs in the System" is an edited volume of multidisciplinary approaches to find constructive options for a "redesign" of the pesticide industry.

  Vorley, W. and D. Keeney, eds. 1998. Bugs in the System: Redesigning the Pesticide Industry for Sustainable Agriculture. Earthscan Publications, London.

USA: Change may bring new economic opportunties- the case of poultry manure:

Meat poultry farms in the USA range in size from over 500 hectare to less than 2 hectares. The size of the farm is often not related to the number of chickens grown and therefore the manure produced may be a credit for the farmer because of its fertilizer value or a debit for the cost of disposal. An industry of clean-out companies has developed to service those farms where manure is a disposal problem. Clean-out companies remove the manure for a fee and then sell the manure to other farmers.

Because the concentration of manure around feedlots has become a severe problem, state governments have begun to legislate mandatory nutrient management programs to protect the environment. For instance those farmers with excess nutrient must adopt transport or treatment measures to prevent excess application of N and P on their land. State funded programs pay farmers a transport fee to move manure to farms that can utilize it effectively. Assistance can also be obtained for the development of new or improved treatment technologies by research institutions and private enterprise.

Principle 2.7 It is necessary to enhance capacity for adaptation to change.

If we are to make sweeping changes in the way our food is produced, and institute a greater reliance on ecosystem services, it should be recognised that under any "change management" there are transaction costs.

The process of conversion from a high-input conventional management to a low-input (or low-external input) management is a transitional process which can have considerable costs for farmers. There are four identified phases in making this transition :

1. Input withdrawal: progressive chemical withdrawal.
2. Efficient input use: rationalisation of agrochemical use through integrated pest management (IPM) and integrated nutrient management.
3. Input substitution: using alternative, low-energy inputs
4. System redesign: redesign of diversified farming systems with an optimal crop/ animal assemblage which encourages synergies so the the system can sponsor its own fertility, natural pest regulation and crop productivity.

During the four phases, management should be guided in order to ensure the following processes:

1. Increasing biodiversity both in the soil and above ground
2. Increasing biomass production and soil organic matter content.
3. Decreasing levels of pesticide residues and nutrient and water loss.
4. Establishment of functional relationships between the various farm components.
5. Optimal planning of crop sequences and combinations and efficient use of locally available resources.

As well, there are a number of constraints that the "change management" regime must contend with. First labor inputs are substantially greater for organic technology than for conventional production; productivity may average 22 percent to 95 percent less than under

An organic agriculture design for the **Peruvian Sierra**

An agricultural NGO implemented an organic agriculture proposal for the region, with basic aspects as:

- rational use of local resources, potentiation of natural resources, and intensive use of human and animal labour.
- High diversity of native (Andean) and exotic crops, herbs, shrubs, trees and animals grown in polycultural and rotational pattersn
- Creation of favorable microclimates through the use of shelterbelts, and living fences and reforestation with native and exotic fruit and trees.
- Recycling of organic residues and optimal management of small animals.

from Altieri 1997

conventional production.

Another constraint is adequate quantitites of organic fertilizer like manure. As livestock production is becoming more and more concentrated in feedlots, whole regions are finding that a shortage of manure on farm is complemented by toxic concentrations of animal waste on feedlots, often near urban areas. This poses the potential for developing sound regional ecosystem interdependencies, but the systems to share such resources in a rational manner need to be developed (see xxx).

Capacity is another large constraint for organic farmers. A study by Blobaum (1983) of farmers in the United States noted that several capacity- and information- related obstacles discourage conventional farmers from adopting organic methods. Organic farmers perceive the lack of access to reliable organic farming information as a serious barrier to conversion. Most rely primarily on information from other organic farmers and from such nontraditional sources as books and magazines, representatitves of organic fertilizer companies, and workshops and conferences. Organic farmers have a strong interest in research on many problems, and most farmers would adopt new practices if more research-substantiated information were available.

Blobaum also found that organic farmers who use special markets are dissatisfied with problems such as small orders, long delays in getting paid, inadequate returns for cleaning and bagging grains, confusing certification standards, difficulty in contacting buyers, and the expense of maintaining special on-farm storage areas.

Credit discrimination is seen as a potential problem by a sizeable number of organic farmers. The long-term economic benefits of organic agriculture may not be evident to a farmer faced with having to make payments on annual production loans. Many conventional farmers are greatly in debt, and their debt constrains the shift to more sustainable methods.

Encouragingly, recent economic evaluations suggest that profits from organic farms can exceed those of conventional farms. Eventually, farmers should be able to reap economic benefits from practising a more sustainable production system. But farmers' inability to overcome the multiple constraints, as listed above, may impede the transition to more sustainable agriculture. The costs of making the transition should not, and cannot, be borne by farmers alone. Governments and non-governmental organisation should seek ways of helping the agriculture sector adapt to changes in ways that benefit all of society.

Governments should appreciate that changes need to be phased and strategically designed. In the case of Denmark, which aims to become a pesticide-free country within five years, considerable work has gone into developing a phased, methodical transition to alternative technologies. The research and logistical development which will be necessary to support this transition come from investment on the part of the Danish government.

Non-governmental organisations can also play important roles in making transitions, particularly when they assist in developing "redesign strategies" (see box). Altieri fournd that in Latin America, NGOs working with communities and applying agroecological methods have shown that transitions to organic production need not be the perogative of developed countries, or naturally productive areas. Even within a policy environment that has not been conducive to sustainable agriculture with a strong political primacy of urban social groups, heavy dependence on industrial production, the absence of effective land distributions, subsidies for fossil-fuel based agricultural inputs, and the limited access of peasants to policital and economic resources, NGOs working with farmer groups have been able to show that low-external input practices can be economically, socially, culturally, and ecologically appropriate for those farmers who have not benefited from conventional agriculture, or farm in marginal areas.

Principle 2.8 Creating popular awareness and education is necessary for change

Ecosystem services may be important, but few people know about them or understand them. Messages on ecosystem services are needed, adhering to the following best practices:

BEST PRACTICES

- Messages on ecosystem services must be simple
- Messsages must target both the public and policy makers
- Information should be packaged for diverse target groups.
- Communicating appropriate knowledge to policy makers is key to appropriate policy formulation.

An initial but by no means comprehensive list of messages which need to be conveyed to the public and to policy makers includes the following:

1. Agriculture depends on the wider environment.
2. Agriculture derives more from environment than technology can substitute.
3. Sustainable agriculture benefits from biodiversity, such as water quality improvement and pollution reduction.
4. Biodiversity benefits can feed back into increased agriculture production, e,g., pollination, or natural pest control can contribute to yield increases.
5. Conversely, loss of pollinators can lead less production and economic benefits
6. These benefits can be quantified.
7. Agricultural practices that maintain soil organic matter also maintain soil diversity.
8. Sustainable economic development is dependent on agrobiodiversity.

A number of creative means need to be undertaken to convey these messages to the public. In the case of the pollination research carried out in Kenya (see box on page 32), research findings were given back to the community and the general public in the form of a colourful poster, distributed through a popular journal. Other innovative public education programmes in relation to soil biodiversity have been started in Australia and Canada (see box).

Public awareness programmes addressing ecosystem services will need to draw on the resources of scientists, and help scientists to work together and with other stakeholders. The Brazilian Government Proposal to the Convention on Biolgical Diversity Subsidieary Body on Scientific and Technological Advice identified institutional and educational factors as the main constraints to effective use of soil biodiviersity (Perez Canhos et al., 1998). These included: low institutional capacity, lack of integration between different groups working on the topics, insufficient information exchange, and lack of public education to appreciate the value of the soil biodiversity. The following goals and strategies were proposed in alleviation:

1. Establishment of a network of laboratories, scientific collections and technical centres.
2. Programmes for education of specialists (Post-graduate programmes in the country and abroad and short courses in the country)
3. Definition of standard sampling protocols

Innovative Programmes of Public Involvement in **Canada** and **Australia**:

Worm Watch is a programme initiated by the Canadian government to promote awareness of the diversity of “life beneath our feet” through public participation in a nationwide earthworm census. The census takers will be students, farmers, producer groups, conservation and naturalist groups, gardeners and interested individuals and families. They will be supplied with a Worm Watch kit containing background material on earthworm ecology and taxonomy, instructions on how to sample and record their data, data sheets, a photographic key showing the most commonly encountered earthworm species, vials for the preservation of earthworms that could not be identified, and a list of references, including a wormwatch website and a toll-free number. An instructional video demonstrating the various sampling techniques should also be available. Scientists will make use of the data collected to inventory and study the distribution of earthworm species in Canada, including correlations between landuse patterns (including undisturbed vs. disturbed habitats, cropping systems, and tillage practices) ecozones, and earthworm populations and species diversity. The data collected should significantly increase the scientific community’s understanding of the biogeography of post glaciation earthworm populations, and the history of their distribution. It can also be used to evaluate the potential of using earthworms as one of a suite of bioindicators of environmentally sustainable land use practices, and the information on species diversity and preferred habitat will beuseful when considering policies on introducing earthworms for waste management, integrated pest management, soil improvement, and site reclamation.

Canada’s WormWatch program is modeled on an Australian program, the Earthworms Downunder, run by CSIRO, the Australian Department of Eduction and the Double Helix Science Club. This programme used Double Helix science club members to collect and determine the diversity and distribution of earthworm species in Australia. The programme was very successful, and accomplished within one year what would be expected of a team of scientists in five years.

from Clapperton, J. no date.

4. Definition of indicators of soil quality
5. Develop models to measure the economic value of the biodiversity of microorganisms and creation of fiscal incentives.
6. Establishment of specialised discussion groups of researchers
7. Establish thematic networks on soil and micro-organisms biodiversity.
8. Education targeting the appreciation of the value of the biodiversity of micro-organisms and their sustainable use and development.

These actions could act as a model for other countries.

3. Principles for Conserving Biodiverse Agricultural Landscapes

We have considered the conservation of genetic resources on-farm, and the conservation of ecosystem services, provided by biodiversity existing on-farm and near farms. In this last section, we will move to a broader perspective, at the landscape level. The landscape level means areas that combine several land-use types, over tracts of land that might be an administrative area, a community territory, a watershed or an arbitrarily determined area several square kilometres in extent. Here, whole ecosystems are involved. The biophysical landscape here includes soils, water and microclimate, all of which can vary within one field, but vary substantially more at landscape level. The ambit includes not only the fields, pastures and agroforests, but also all areas of managed or unmanaged fallow and wild land within, among and around agroecosystems.

It is largely at the landscape level where agriculture interacts with wild biodiversity. Loss of wild habitat to agricultural use is usually given as the largest threat to the planet's wild biodiversity. It is critically important for biodiversity planners and agricultural policy makers to pay attention to those borders and balances between agriculture and protected areas. While agriculture is often seen as incompatible with wild biodiversity, several strategies are available to make more space for wildlife in agricultural landscapes. Under some conditions, increasing agricultural productivity on existing farmlands will reduce the expansion of farming onto new lands, or even encourage the contraction of production areas. Meanwhile, in and around existing farmlands it is often possible to identify spaces that can be maintained as protected areas, either as larger reserves, or as habitat networks in production areas. Many new approaches suggest that landscapes can be managed for both the production of food and the conservation of wild biodiversity (McNeely and Scherr, in press).

No agricultural system can be understood independently from the manner in which management is organized and the forces that interact to shape this organization. Management involves farmers and their families, community leaders and others, and in modern times also officials of government and agriculture departments. The layout of farms, the rotation of their land-use stages and field types, are all determined by those who manage the farms and the biological landscape within which farms operate. Thus, as we look at conservation of biodiversity in agricultural landscapes, we also include a consideration of the knowledge systems and differential abilities which determine management practices.
Key prinicples for the conservation of landscape level diversity, wild biodiversity in agricultural landscapes, and knowledge systems for agrobiodiversity are:

3.1 Protected areas are desirable near farming areas, ranch land and fisheries

3.2 Farm resource management practices can be modified to enhance habitat quality in and around farmlands

3.3 Conservation and management of biodiversity will be optimized by varying degrees of agricultural intensification on a landscape. Thus, NBSAPs should promote policies that will maintain the diversity of land use across the landscape.

3.4 NBSAP planners need to recognize and utilize traditional practices as a component of the knowledge system that support conservation and management of agrobiodiversity.

3.5 NBSAP planning needs to take account of the fact that different ecologic and socio-economic differences between farmers make it easier for some to manage biodiversity than others and that these difference are widening, thus new instruments for conservation may be needed.

Principle 3.1 Protected areas are desirable near farming areas and grazing land.

Historically, most protected areas were established in and around lower-intensity rainfed agricultural systems, where land values and productive potential were relatively low. Even in these areas, however, their value for local people may still be significant, and without local people's "buy-in" to the site boundaries, it has been difficult to ensure those boundaries.

Biodiversity conservation initiatives are increasingly being targeted at lands with much higher value for agriculture. In such cases, a much clearer analysis of tradeoffs is needed, and evidence of potential benefits of conservation for the surrounding farmers must be rigorously produced. Where it isjustifiable to take or keep land out of agricultural production in order to establish protected areas, it is critical to obtain the support of local agricultural populations. This is likely to be in conditions where:

1. the site clearly helps to make farming more productive or sustainable (e.g., by protecting valued pollinators);
2. the reserve helps to protect locally-valued environmental services (e.g., good water quality);
3. the site offers attractive alternative livelihood options (e.g., by enhancing fishing income or attracting tourists);
4. farmers are adequately compensated for the loss of land or helped to make the transition to an equally attractive livelihood option (e.g., with payments for biodiversity services); or
5. local communities themselves value the aesthetic, cultural, or recreational aspects of the habitat or of particular species (e.g., to protect sacred groves from development by outsiders).

One of the clearest benefits to farmers from protected areas is watershed protection. The same good natural vegetative cover needed to maintain healthy watersheds to produce a steady and reliable source of water, may also provide good biodiversity protection. For example, La Tigra National Park in Honduras with 7600 hectares of cloud forest provides a critical water supply to the capital city of Tegucigalpa (40 percent of its drinking water at a cost of about 5 percent of its second largest source) and farming communities downstream. Guatopo National Park in Venezuela provides 20,000 liters per second of high-quality water to Caracas, but also to agricultural users. In northern Thailand, quite large upper-catchment areas are conserved from agriculture for watershed protection.

Gradually, the role of protected areas in providing other ecosystem services such as pest control and waste recycling, is gaining recognition (see Box, Cosat Rica). Yet communities and traditional societies have long set aside protected areas for multiple functions. The village of Missidè Héïré for example, in the Fouta Djallon of Guinea, reserves 3.1 ha of

> In **Costa Rica**, a large company produces oranges next to the Guanacaste Conservation Area as well as in many other places throughout the country. They realized that their plantations next to the protected area had few pests, and year-round secure water supply. They also wished to use the natural woodlands to let their orange residues decay, instead of otherwise having to dispose of them. As they needed to use far less pesticides next to the forest, they were concerned to see that the protected area is well maintained, and consented to pay an equivalent of almost half a million dollaors over 20 years to the reserve.
> from Jeff's full draft

forest and 15.6 ha of woody savanna immediately adjacent to its 27.2 ha of intensively-cultivated infields for the gathering of fuelwood, medicinal and other useful plants, for religious reasons and also for protection from seasonal fire arising in the surrounding outfields and fallow areas (Boiro et al. 2002, forthcoming). It is important to recognize that such conservation arrangements do occur at local level, without external imposition. Planning for new protected areas in agricultural land should build on local residents' understanding of land conservation benefits.

An interesting new development is occurring, with reserves being set up to protect agricultural genetic resources, or their close wild relatives. In recognition of the fact that ***in situ*** conservation allows species to continue to co-evolve in relation to their natural environment, associated pests, and human selection pressure, conservation efforts for wild relatives of domesticated crops have sometimes also been linked to establishment of protected areas that include working farms (Amaral, Persley and Platais 2001). Reserves currently exist for maize in Mexico, wheat in Israel, and a country-wide program funded by the Global Environment Fund (GEF) in Turkey (Hodgkin and Arora 2001). India has established a "gene sanctuary" in the Garo Hills for wild relatives of citrus and further sanctuaries are planned for banana, sugarcane, rice and mango (Hoyt 1992). The Chatkal Mountain Biosphere Reserve in Kirgizstan conserves important wild relatives of walnuts, apples, pears, and prunes. These programs seek to preserve farming areas and nearby wildlands, usually with some restrictions on management and harvest to protect wild biodiversity.

BEST PRACTICES

- Establish protected areas near farming areas, ranch land, and fisheries where both rural populations and wild biodiversity can mutually benefit.
- Involve local farmers and organizations in the planning of protected areas.
- Involve the ministry of agriculture in the planning of protected area systems
- Provide incentives for farmers to cooperate.

Protected area planning information
World Commission on Protected Areas?
Conservation handbook?

Priniciple 3.2 Modify farm resource management practices to enhance habitat quality in and around farmlands.

The following discussion borrows heavily from the text of the expert review on wild biodiversity in agricultural landscapes, commissioned from J. McNeely and S. Scherr.

BEST PRACTICES

- Promote increases in agricultural productivity that expressly lead to a contraction in agricultural lands and reversion to wild vegetation
- Modify resource management with a concern for wildlife.
- Use non-agricultural land in farm landscapes in biodiversity-friendly ways
- Recognise sources of conflict between agriculture and wildlife, and plan for it, or compensate for it.

One means of modifying farming practices to accomodate the needs of wildlife is to promote increases in agricultural productivity that expressly lead to a contraction in agricultural lands and reversion to wild vegetation. The trends, of course, are presently in the opposite direction: pressure for agricultural expansion often results from incentives to expand profitable production systems. But in many cases, the pressure results from stagnant agricultural productivity in the face of rising market and population pressures, lack of agricultural employment that induces the landless to seek unexploited lands, and degradation from unsustainable intensification in lower quality lands that leads to land abandonment. Increases in agricultural productivity and sustainability may help to slow or reverse these latter processes

McNeely and Scherr in our wild biodiversity expert review have compiled a series of documented cases where increases in agricultural productivity have led to a contraction in agricultural lands, and reversion to wild vegetation. All of these took place in farming systems in marginal lands that relied on short fallows. Intensification of production on the best (irrigated, or more fertile) lands permitted farmers to withdraw from (or slow expansion into) more extensively managed fallow areas. Their example of regenerating native pine forest habitat in Honduras through improved crop technology is given in the box below.

Another important means of accomodating wildlife in agricultural landscapes is through modifications in the way resources are used. Habitat quality of farmlands can often be improved by changing water, soil and plant resource management in ways that have neutral or even positive effects on agricultural production. There is great scope for increasing use

Honduras: The central region of Honduras covers about 8,900 square kilometers, of which over 90 percent is rugged hillsides. All was originally forested; about half of the area today is covered by native pine forest, with scattered deciduous forest stands. Significant deforestation occurred prior to the mid-1970s, due to over-logging and frontier agricultural settlement. Since then, commercial logging has been sharply controlled. However, conversion of forest to farmland has continued as a result of a 2.3 percent annual rural population growth, agricultural demand from the even faster-growing capital city nearby, and widespread erosion and nutrient depletion in steep fields used for low-value staple food crops. As a result of loss of forest habitat, wild populations of deer, agouti, raccoon, various squirrels (which have traditionally provided an important source of animal protein for local diets), as well as other native fauna and flora have declined sharply.

But a different pattern of land use change has emerged in some of the region's communities, as a result of research and extension by National Coffee Program of Honduras and by the local Pan-American Agricultural School of Zamorano. In the 1980s the Zamorano School identified a wide range of fruit and vegetable varieties suitable for local steepland conditions, and developed integrated nutrient and pest management strategies and sprinkler irrigation and conservation practices. The Coffee Program encouraged coffee-growing communities to intensify production of basic grains, to free up farmland to expand shade coffee area, and plant higher-yielding coffee to replace traditional varieties. In the late 1980s and early 1990s, communities occupying a third of the area of the Central Region adopted and adapted these new technologies. Higher cash incomes from vegetables and coffee enabled farmers to purchase fertilizers to replenish soil nutrients both in their commercial fields and in subsistence staple food crops, thus nearly doubling maize yields on permanent fields. This allowed them to abandon marginal fallowed fields, which reverted to forest. Aerial photograph analysis shows that the net area under forest cover remained stable during this period in the coffee-growing communities and declined only slightly in the horticultural communities. This contrasts with at least 13 percent, and in some cases as high as 20 percent, forest cover decline in the basic grains communities. Unlike the extensive farming communities, these did not report a decline in wild game over the period; indeed, their reliance on hunting for game declined (Pender, Scherr and Durón 1999; Scherr 2000).

efficiency of both rainwater and irrigation water in agriculture, thus making more water available for wetlands and wildlife. Better management of drainage water in irrigation systems can prevent salinization of soils and water, and resulting radical changes in habitat quality. Water conservation measures can help to slow the velocity of water moving across the surface, encouraging better percolation through the soils and availability of water for non-crop plants.

Natural vegetation in farmlands can be better managed for both habitat quality and production. It used to be common wisdom that fallows would have no role in the permanent agriculture of the future. Over the past decade, however, researchers working together with farmers have developed short-duration, improved woody fallows for many tropical agroecosystems. Because they reduce farmers' cash costs for purchase of fertilizers and produce a range of valuable products for household use or sale, the practice has spread rapidly, even on small farms. Short fallows, using trees, shrubs or herbaceous plants, can enhance wild biodiversity by reducing agro-chemical pollution and providing suitable habitat. Fallow systems provide mosaics of spatially interacting fallow and cropped plots (van Noordwijk 1999); these can be an important part of broader land use mosaics to enhance wild biodiversity.

Simple changes in the treatment of crop residues at the end of harvest may benefit wildlife. A study of the northeast region of the U.S. has shown that numbers of wild turkeys, Canadian geese, deer, raccoons, skunks and possums have increased where farmers leave more crop residues in autumn and winter (Mac ***et al***. 1998).

Resource systems may be modified by focusing more on production of wild species for consumptive use. The establishment of large wildlife reserves in traditional grazing areas, with sharp restrictions on local rights to graze and to destroy wildlife threatening their cattle, has caused conflict and exacerbated poverty. In response, new paradigms have been developed for co-managing domestic livestock and wildlife (Bourn and Blench 1999; IFAD 2001; Kiss 1990). Research has shown that livestock and wildlife exploit different (but overlapping) ecological niches in time and space, and have evolved different physiological and behavioral strategies to reduce competition. Some experts now advocate mixed livestock raising and harvesting of wild herbivores as the most economic use of low-rainfall rangelands, thus maintaining the full natural biodiversity (Western and Pearl 1989). While maintaining income and use values from livestock, the new strategies also benefit pastoralists economically by integrating wildlife into their livelihood strategies, earning income from eco-tourism, safari hunting, park revenue sharing, cash compensation for the risks of wildlife damage, sale of rangeland products to tourists. For example, the CAMPFIRE community-based wildlife management program in Zimbabwe has increased incomes in communal areas by an estimated 15-25 percent (Butler 1995), though household level income increases may be less. Research in Ghana, Kenya, Zimbabwe, and Namibia showed significantly higher economic rates of return on wildlife ranching than from cattle, though the income from tourism, trophy hunting, and wild meat is subject to market saturation (Bojos 1996).

In most agricultural landscapes, even those with intensive farming systems, considerable land area is devoted to non-agricultural uses. These include obvious features, like farm wetlands, wood lots, or windbreaks, but also often-ignored sites like schoolyards, temple grounds or graveyards (see box, Non-cultivated areas). There is often more wild biodiversity present than most people realize, and considerable scope to protect or enhance those resources. Thus, a third major strategy to promote biodiversity in agricultural regions is to modify the use of those “in-between” spaces, to provide better ecological conditions for wild biodiversity to thrive.

No matter how carefully they are protected, small reserves will progressively lose their most distinctive species if they are surrounded by a hostile landscape. But if the surrounding matrix is managed with biodiversity in mind, agricultural areas can make a positive contribution to biodiversity. The greatest potential for meeting biodiversity conservation goals is by establishing habitat according to an integrated pattern within and across farms that reflects landscape-scale ecosystem planning. Different types of niches in agricultural landscapes, depending upon their size, shape and location, may support different types of biodiversity. Non-farmed areas can be utilized to provide "patches" of certain types of habitat, or to form "corridors" linking protected areas and enabling species to maintain genetic contact between populations that otherwise would be isolated. This may involve protecting remnant native vegetation or re-establishing wild species, often "keystone" species that provide micro-habitats for associated species. Remnants may

Non-Cultivated Areas in Agricultural Lands: Potential Habitat for Wild Biodiversity

Around water resources:

- Riparian forests and ecosystems
- Natural waterways
- Irrigation canals
- Watershed areas to promote water harvesting
- Farm, road and other drainage ways
- Drainage water used for fish habitat or production
- Stream filter strips (using native and a variety of usable components), to catch sediment and chemical run-off

In and around farm fields:

- Conservation reserve areas taken out of farming
- Uncultivated strips within crop fields as habitat for weeding relatives of crop plants, especially in areas known to be centers of origin or diversity for crop plants
- Windbreaks
- Border plantings or live fences between plots or paddocks, or between farms
- Irrigation bunds
- Vegetative barriers to soil and water movement within crop fields
- Areas taken out of production to control salinity, or abandoned as a result of salinity
- Little used or low-productivity croplands
- Little used or low-productivity grasslands

In and around forest areas:

- Farm or community woodlots
- Farm, community, government or private natural woodlands or forest
- Private industrial plantations

Other sites:

- Homesteads
- Along roadsides
- "Sacred groves" in communal lands, churchyards or graveyards
- Schoolyards
- Agroindustrial or hospital sites
- Agro-ecotourism sites
- Public or private recreational parks
- Special sites conserved for cultural value to indigenous people

include both biological communities that depend on a continuation of traditional land use practices, and survivors of pre-agricultural vegetation. Through various kinds of linkages with the surrounding landscape, protected areas can avoid becoming fragmented and degraded and become more effective in conserving biodiversity.

While we still have much to learn about ecological relationships between wild species and agricultural habitats, some general principles are developing. We know that since many vertebrate and insect species use and require two or three habitats diurnally, seasonally, or in their life cycle, the proximity and access to such habitats is critical (Forman 1995). Networks of natural vegetation are particularly effective for maintaining populations of "edge species," and for connecting breeding stocks in dispersed protected areas. Such networks could potentially meet a significant part of the habitat needs for many types of species, even

USA: Managing flooded rice fields for wildlife habitat

Flooded fields apparently provide foraging habitat equivalent to semi-natural wetlands and, because of reduced predation threat, may be a safer habitat for waterbirds. Thus if managed appropriately one of the world's dominant forms of agriculture can provide valuable waterbird habitat. For example, flooded rice fields in California are used by numerous aquatic birds during winter. This habitat functions like more natural wetlands, so increased flooding may help replace the extensive wetlands that occurred in the region prior to agricultural development (Elphick 2000). Researchers compared the habitat value of flooded rice fields and semi-natural wetlands for several species of aquatic bird. The availability of invertebrate species used by birds for food did not differ among habitats. Semi-natural wetlands had less rice grain but more seeds from other plants than the two rice habitats. Predators passed over a feeding area less often in flooded fields than in unflooded fields or semi-natural wetlands, but birds fed more often in flooded fields.

Such results are relevant in many parts of the world. In the Sacramento and San Joaquin Valleys of California, farmers working together in the Valley Care program have instituted minor management changes in flooded rice production that have greatly increased their value for tropical migrant shorebirds and waterfowls. These methods were pioneered by Ducks Unlimited, a conservation and hunters' organization. After rice is harvested, rice stubble and straw are rolled and crushed, and then flooded over the winter as an alternative to burning it. The system accomplishes the grower's objective of decomposing waste straw and controlling weeds and diseases, while providing winter habitat and food for waterbirds. Rolling rice straw is economical in comparison with alternative agronomic methods that do not have the same wildlife benefits, and also eliminates air pollution due to burning, which is now tightly regulated. Some restored natural wetlands are being managed jointly with agricultural lands to provide year-round wildlife habitat. Species benefiting are not only waterfowl (like ducks) but also wading birds, shorebirds and cranes. Shorebirds include dunlins (*Calidris alpina*), dowitchers (*Limnodromus scolopaceus*), killdeers (*Charadrius vociferus*), and other sandpipers. Ducks included northern pintails (*Anas acuta*), American widgeons (*A. americana*) and even mallards (*A. platyrhynchos*) and northern shovelers (*A. clypeata*). Snow geese and Ross' geese were also common (Paine, Bias and Kempka 1996). The rice cropping system in the upper coast of Texas creates a heterogeneous mosaic of flood rice wetlands, grazed fallow lands, and ploughed fields, that has dramatically increased use by migratory birds like the lesser snow geese, the greater white-fronted geese and Canada geese. Over 20 million waterfowl and geese winter on the upper Texas coast, with the bulk of these using freshwater wetlands associated with rice agriculture (Lacher *et al*. 1999).

without large protected areas nearby. In western Australia researchers found that even modest increases in native vegetation from 7 to 10 percent, strategically located, significantly improved habitat value (C.Binning, pers. comm. 3/01).

Even small fragments of native habitat can help migratory animals at sites that provide food and shelter for specific periods of the year. Many migratory species of birds, for example, will find these relatively small areas of habitat sufficient to meet their transitory needs. Recent studies of insect-eating birds in isolated fragments in Brazil have indicated that the rapid establishment of tall secondary forests around small fragments linking them back to more extensive primary forest areas and greatly accelerates the recovery of the avian insectivore community to something close to the pre-isolation situation. Thus small fragments can provide a safety net for a significant number of species and their genetic diversity, and a breathing space for conservationists to plan strategies for preventing the loss of the species concerned. Intervention management can then be focussed on species that are particularly sensitive to fragmentation, such as large carnivores, large trees, and epiphytic orchids. For example, Cowlishaw (1999) concludes that 30 percent of forest primate fauna will be lost even if deforestation is controlled, unless corridors to connect protected areas are established.

Many farmers are interested in wildlife conservation, where it can be done without signifi-

Costa Rica: Farmland corridors

In 1989, the Conservation League of Monteverde, in a wet, mountainous region of northeast Costa Rica of high natural biodiversity value, initiated tree-planting activities with farmers. The project worked in 19 communities, and helped farmers to establish over 150 ha of windbreaks. The windbreaks, a mix of indigenous and exotic tree species, were designed to protect coffee trees and dairy cows from the negative impacts of high winds. The economic returns from windbreaks to the farmers are very high, even without considering timber products, as wind protection results in higher coffee and milk yields, reduced calf mortality and morbidity, and larger herd-carrying capacity of pastures. Nearby farmers also established windbreaks that allowed the production of high-value horticultural crops in the protected fields. Damage to coffee from wild parakeets has been reduced, because the parakeets prefer the fruit of a native tree known as colpachi, one of the species used in the windbreaks. Furthermore, farmers who received benefits from the windbreaks have been more receptive to efforts to protect the remaining natural forest on their farms (Current 1995).

Research has shown that the planted windbreaks serve as effective biological corridors connecting remnant forest patches in the Monteverde area. These corridors are especially useful for the migratory species of songbirds that are an essential part of agroecosystems in North America during their summer breeding season. The windbreaks also dramatically increased the deposition of tree and shrub seeds within the agricultural landscape. A careful study of annual "seed rain" patterns in the windbreaks and adjacent patterns found that seeds deposited in the windbreaks represented 174 species and at least 53 plant families. Trees accounted for a third of all species. Epiphytes and trees were primarily bird-dispersed, whereas herbs were primarily dispersed by wind, gravity or explosive mechanisms, and shrubs by a combination of mechanisms. These windbreaks were only 3-7 meters in width, yet they increased seed deposition by birds over 95-fold relative to the pastures. They were effective despite consisting of primarily exotic, nonfruit-bearing species that offered no food resources for birds. If native, fruit-producing trees were incorporated into the windbreaks, it is likely they would enhance the incoming seed rain and species richness further (Harvey 2000) cant financial loss or livelihood risk. For example, farmers have worked to recover native or endemic species now rare in the landscape, by converting low-value unfarmed areas to native vegetation, or preserving biodiversity-rich wetlands. In ranching systems, landowners and community groups have allocated marginal grazing lands to help conserve wild species. For example, a large-scale row- and field-crop farm in central California incorporated over 50 locally adapted species of native perennial grasses, forbs, sedges, rushes, shrubs and trees into various parts of the farm — on poor quality lands, roadsides, irrigation canals, natural sloughs, tailwater ponds and hedgerows. The 200 hectare farm has 3 ha of 5-10 meter wide multi-species hedgerows that serve as year-round "habitat highways" for deer, fox, bear, coyotes and many other animals, whose populations have dramatically increased. They act as a web connecting the other native habitat patches, as well as supporting beneficial insects that control pests in adjacent row crops. While the farmer faces additional costs for seed and plant materials, special equipment, and increased transportation due to limited local markets for the native grass seeds, cost savings are achieved from reduced pesticide use, labor and tillage. Field studies demonstrated no meaningful difference in crop yields, and implementing practices in unfarmed areas has caused little or no reduction in the land available for crops (Anderson ***et al.*** 1996). In Ontario, Canada, a farm survey found that in 1999 77 percent of farmers felt wildlife was "very or somewhat important as a necessary part of the balance of nature", and farmers had invested a total of almost $8 million in enhancing wildlife habitat (Ontario Soil and Crop Improvement Association 2001).

Philippines: Soil erosion barriers with native plants

Contour hedgerows are rows of perennial shrubs established along the contour that have been promoted on steeplands to reduce erosion and produce organic matter for soil improvement. Most contour hedgerows have used exotic grass or shrub species, requiring special nursery development to provide planting materials and considerable labor for establishment. In the early 1990s, researchers at ICRAF in the Philippines, frustrated at farmers' low adoption of hedgerow technology, began a series of studies to identify the most cost-effective approach to contour planting of perennials. They discovered that natural vegetative strips (NVS) — contour rows left uncultivated during plowing, so that natural vegetation could grow there — were not only the least expensive (zero cost for planting materials and establishment), but erosion control was nearly as effective as in planted shrub hedgerow technologies. Studies found rows as far apart as 2 to 4 meters elevation distance served nearly as well for erosion control as more closely-spaced rows, while removing much less area from production (Mercado *et al.* 1997). Further research developed a very low-cost method for laying out initial contour lines, and for enriching the natural vegetative strips with high value fruit trees from which farmers could earn cash income.

First introduced to NVS in 1996, thousands of farmers have now adopted this low-cost technology in the densely populated steep farmlands of northern Mindanao, the Philippines. The natural vegetative strips are not only valuable for maintaining soil fertility on farms and protecting local watersheds, but they also provide important habitat for wild biodiversity. A study of floral composition and community characteristics of fields with NVS confirmed the high diversity of native plant species, while the presence of untilled areas provided habitat for native fauna (Ramiaramanana 1993). Economically profitable timber and fruit tree species in the NVS further expand their habitat value for wildlife.

It is often desirable to include in plant mixtures species that produce products that are economically valuable, for cash sale or for household consumption. These can help to meet the livelihood needs of farmers, as well as important environmental functions. While they may modify habitats somewhat, their advantage is in providing financial incentives for farmers to maintain them over the long term. By enriching the natural vegetation growing in between farm fields with nutritious food species, the nutritional status of local people can be improved. Native vegetation established in non-farming areas, such as roadsides or schoolyards, can include food or fuel plants to be harvested by the poor. Even if not all vegetation in these "in-between" sites is native, increasing below and above-ground biodiversity will often be ecologically valuable. Inclusion of exotic species that provide products of value to farmers can encourage participation in biodiversity conservation, and may be considered wherever their establishment represents a net improvement in overall habitat quality and does not threaten to become invasive.

Two cases (see boxes) illustrate how wildlife habitat can be created "in-between" agricultural production areas, to the mutual benefit of farmers and wild species.

While identifying ways to support populations of wildlife in the midst of agricultural regions, it is important, however, to note that peaceful co-existence is not always the result. Important conflicts may arise. Increased wild bird populations (e.g., parrots) may consume standing crops or infect poultry with disease. Some wild animals may behave as predators on domestic livestock (e.g., wolves or lions). Some herbivores may raid crops, such as elephants, wild pigs, or rhinos; and some aggressive native or non-native plants may infest farm fields (e.g., weeds such as ***Imperata*** or ***Lantana***). Some species feed on stored crops (eg. rats, mice). Other wildlife may represent a potential threat to human life and health (e.g., poisonous snakes, tigers). Indeed, concerns about such threats led to many of the original decisions by farmers or whole communities to clear native vegetation and remove potential wildlife habitat. Farmer resistance to increasing wildlife populations can be considerable, even among individuals with a strong philosophical commitment to environmental values. Even so, "ecoagriculture" implies active co-management of both agricultural production and wildlife.

Ecological research over the past few decades has shown that strategic interventions can often significantly reduce the number of actual conflicts with resident or visiting wildlife. Some wild predators actually serve to control agricultural pests, and are thus beneficial to farmers. Measures that have been implemented successfully in various parts of the world include: modifications in livestock husbandry (everthing from lambing and kidding in sheds to putting bells on their sheep); fencing (species-specific requirements); guarding animals (such as donkeys in sheep and goat flocks); repellents and frightening devices; or maintaining wild populations of snakes or owls to control rats (USDA 1994). Near large wildlife reserves, digging trenches has proven effective in discouraging elephants and rhinos. Some types of weeds can be controlled with modified grazing regimes, and bird and insect pests has been successfully controlled by establishing plants that provide alternative feed and water sources. Some pests can be controlled by managing pest-predator populations. Selective destruction or removal of problem animals can be done. Considerable research is required to devise and document the efficacy of wildlife control methods for specific species and ecoagrosystems.

Recognition of potential problems is an important part of ecosystem planning, and monitoring of farm-wildlife interactions to enable corrective measures to be taken is an essential parts of the ecosystem management process. Especially promising ways to enhance agriculture-wildlife coexistence are strategies whereby local farming populations benefit directly from the presence of wildlife in their landscapes, through sharing of ecotourism revenues, direct harvesting of wild products, public assistance with wildlife control measures, or payments for biodiversity services provided (Kiss 1990). Where conflicts are unavoidable, mechanisms must be put in place to compensate farmers fairly for their losses (Tisdell 1999).

TOOLS

- A review of measures to mitigate human/wildlife conflict is catalogued at this website. For example, near wildlife reserves, digging trenches has proven effective in controlling the movement patterns of elephants and rhinos. Internet Center for Wildlife Damage Management.

  www. ianr.unl.edu/wildlife/solutions/handbook.

- This small booklet provides some guidance on managing agricultural landscapes for pollinators:

  Matheson, A., ed. 1994. Forage for bees in an agricultural landscape. International Bee Research Association. Cardiff, UK.

Principle 3.3 Conservation and management of biodiversity will be optimized by varying degrees of agricultural intensification on a landscape. Thus, NBSAPs should promote policies that will maintain the diversity of land use across the landscape.

Once we enter into a discussion of landscape-level management, questions of land tenure, property rights, and management authority need to be addressed, as these clearly have the strongest impacts of any policy interventions on landscape level diversity.

From the standpoint of agricultural biodiversity conservation, land tenure systems which permit security of tenure and landholder investment in conservation activities is needed. Moreover, a long history of research on land management systems has shown that the most innovative land stewardship systems come from flexible tenure arrangements (Brookfield 2001). But is too often the case that land tenure conditions are imposed from above, without adequate knowledge of indigenous systems, in particular social systems under which people can use their personal networks to access additional land, obtain assistance where it is needed, and help one another. Sometimes indigenous systems of tenure are quite deliberately disregarded, and new conditions are imposed that reflect the views held at state level concerning what proper land arrangements should be. A more sensitive approach to indigenous land rights is only slowly taking shape, and being applied in the management of relations between the state and its rural citizens.

An important distinction can, however, be drawn between countries and regions in which the state claims title to land, and allocates it to individuals on a legal basis, and those in which private arrangements continue to hold sway. One important aspect of colonial rule was the assumption by the state of title to all land not in current use, and sometimes to land in use as well. This has continued beyond the end of colonialism in many areas, among which the shifting-cultivation areas of Indonesia are a striking example (Brookfield, Potter and Byron 1995). Re-allocations took place, forcing people to occupy new areas, and to surrender large tracts of land to settlers, or companies.

NBSAP planning, like national agricultural policies and national environmental policies, are also top-down arrangements, and it cannot be said that any of those so far prepared take adequate account of the variety of land tenure arrangements that exist. Nor do they take account of the consequences in terms of inequality that make imposition of any set of uniform strategies an impossible goal. It is therefore important that in the development of such policies, there be consultation at local level on the implementation of strategies, and that this consultation be fully participatory among the farming populations who will be expected to conserve agrobiodiversity.

It is also important that other policies, in addition to land tenure policies, which promote diversified forms of managment, be promoted, and that political space be created for community and voluntary initiatives to promote diverse and appropriate land management schemes.

BEST PRACTICES

- Review polices for relevant sectors and be proactive about a dialogue on plans (strategic EIA).
- Review tenure policy over land, and biodiversity.
- Support and encourage community initiatives to promote diverse and appropriate land management schemes.

Policies that work for sustainable agriculture (and landscape-level biodiversity conservation)

Policy 1: Declare a national policy for sustainable agriculture.

Encouraging resource-conserving technologies and practices
Policy 2: Establish a national strategy for IPM
Policy 3: Prioritise research into sustainable agriculture
Policy 4: Grant farmers appropriate property rights
Policy 5: Promote farmer-to-farmer exchanges
Policy 6: Offer direct transitionary support to farmers
Policy 7: Direct subsidies and grants toward sustainable technologies
Policy 8: Link support payments to resource conserving practices
Policy 9: Set appropriate prices (penalise polluters) with taxes and levies
Policy 10: Provide better information for consumers and the public
Policy 11: Adopt natural resource accounting

Supporting local groups for community action
Policy 13: Encourage the formation of local groups
Policy 14: Foster rural partnerships
Policy 15: Support for farmers' training and farmer field schools
Policy 16: Provide incentives for on-farm employment
Policy 17: Assign local responsibility for landscape conservation
Policy 18: Permit groups to have access to credit

Reforming external institutions and professional approaches
Policy 19: Encourage the formal adoption of participatory methods and processes
Policy 20: Support informaiton systems to link research, extension and farmers
Policy 21: Rethink the project culture
Policy 22: Strengthen the capacity of NGOs to scale up
Policy 23: Foster strong NGO-government partnerships
Policy 24: Reform teaching and training establishments
Policy 25: Develop capacity in planning for conflict resolution and mediation

from Pretty 1995

Policy reform in agriculture is under way in many countries, with some new initiatives supportive of more environmentally sustainable modes of production. Most of these focus on input reduction strategies. Only a few as yet represent coherent plans or processes for integrated management of agriculture and biodiversity. Nonetheless, in cumulative total, the policies listed in the accompanying box can lead to substantive changes in the way agricultural land is managed with respect to conservation of biodiversity. They could have even more impact is they could be integrated into a strategic environmental impact assessment on the environment and agriculture.

The literature on land tenure and environment is voluminous, and does not need to be invoked here. But experiences in tenure policies for rural populations over the wildlife which occurs on their land is a special case of land tenure issues that deserves mention. The experience of CAMPFIRE, in Zimbabwe, is informative (see box next page)

Informally there are many documented instances of local community initiatives that take "landscape approaches" to the conservation of key sites within a landscape; some instances are mentioned in section 3.1 A formal version of these initiatives is the Landcare Movement in Australia, and South Africa, which is premised on a perception by farmers that they themselves benefit from having "protected" land adjacent to their farms. The movement consists of groups of farmers who support one another and work together on a landscape scale to improve the agroecosystem. There are some 4,500 such groups now working in Australia. To take one example of 14 families in New South Wales, together they have addressed soil erosion, feral animals and introduced weeds. With community and government support, they have fenced a "local protected area", and removed all weeds and feral animals, and reintroduced their native wallabies. The "local protected area" is not only good for biodiversity conservation, but is a cornerstone of their campaign to fight gully erosion and land degradation. Protection, in this case, need not be by a government body, so long as community sanctions are in place.

Principle 3.4 NBSAP planners need to recognize and utilize a diversity of knowledge systems, including traditional practices, that support conservation and management of agrobiodiversity.

The following discussion borrows heavily from the text of the expert review on knowledge systems, commissioned from P. Mulvany.

Agricultural biodiversity is the product of human ingenuity: it embodies the knowledge of generations from since some 10,000 years BC. That knowledge is bound into the genetic, species and agroecosystem diversity through countless managed adaptations of interactions between species (and subspecies, varieties, breeds, etc.) that have been the result of human initiatives. Thus, all agricultural biodiversity activities are based on knowledge systems that stretch from the birth of agriculture to the present day.

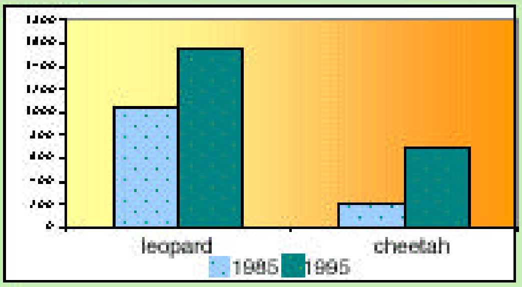
BEST PRACTICES

- Be aware of the diverse proposals on the international level to manage knowledge systems.
- Address national options for managing knowledge systems and respecting ownership and rights over traditional knowledge.
- Develop means of respecting community rights.

Zimbabwe: Since 1975, Zimbabwe has allowed private property holders to claim ownership of wildlife on their land and to benefit from its use. Zimbabwe has pioneered consumptive uses of wildlife with its Communal Area Management Programme for Indigenous Resources. CAMPFIRE, emerged in the mid-1980's with the recognition that as long as wildlife remained the property of the state no one would invest in it as a resource. CAMPFIRE is a programme than has sought to give rural communities an alternative to destructive uses of the land by making wildlife a valuable resource, on the thesis that wildlife is the most economically and ecologically sound land use in much of Zimbabwe. Through CAMPFIRE, Zimbabwe seeks to involve rural communities in conservation and development by returning to them the stewardship of their natural resources, harmonising the needs of rural people with those of ecosystems. Under CAMPFIRE, people living on Zimbabwe's impoverished communal lands, which represent 42% of the country, claim the same right of proprietorship. Conceptually, CAMPFIRE includes all natural resources, but its focus has been wildlife management in communal areas, particularly those adjacent to national parks, where people and animals compete for scarce resources. Since its official inception in 1989, CAMPFIRE has engaged more than a quarter of a million people in the practice of managing wildlife and reaping the benefits of using wild lands.

CAMPFIRE begins when a rural community, through its elected representative body, the Rural District Council, asks the government's wildlife department to grant them the legal authority to manage its wildlife resources, and demonstrates its capacity to do so. By granting people control over their resources, CAMPFIRE makes wildlife valuable to local communities because it is an economically and ecologically sound land use. The projects these communities devise to take advantage of this new-found value vary from district to district. Most communities sell photographic or hunting concessions to tour operators - under rules and hunting quotas established in consultation with the wildlife department. Others choose to hunt or crop animal populations themselves, and many are looking at other resources, such as forest products. The revenues from these efforts generally go directly to households, which decide how to use the money, often opting for communal efforts such as grinding mills or other development projects. The councils, however, have the right to levy these revenues.

The Parks and Wildlife Act gives privileges to owners or occupiers of private land and rural district councils in the case of communal areas to utilise and exploit plants and animals on their land. Conservancies are mostly located in areas of low agricultural potential where wildlife is the only viable and sustainable form of land use. Its success, next to the traditional competition between agriculture and wildlife, is seen in the following results: domestic stock predators such as lion, cheetah and leopard which were being eradicated to safeguard domestic stock before the legislation and policy changes were put into place, have now started to increase in umbers. For example, surveys on 206 game and game/cattle ranches (for leopard) and 37 ranches (for cheetah) showed the following changes between 1985 and 1996:



On average CAMPFIRE projects in Zimbabwe generate over Z$20 million annually. In addition to income directly accruing to participating households from the CAMPFIRE programme, local authorities have put up schools, grinding mills, electric fences and sales depots using revenue from the programme. Communities which include both the large scale commercial farmers running conservancies/game ranches and smallholder farmers involved in the CAMPFIRE programme are key players in sustainable wildlife management.

Global initiatives:

The International Environmental Governance structure has dealt with knowledge systems in a number of ways, which need to be considered in relation to agricultural biodiversity.

Under the Convention on Biological Diversity Article 8j, indigenous knowledge is recognised as connecting the knowledge systems directly to a social group:
Subject to its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote their wider application with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilisation of such knowledge, innovations and practices.

The United Nations Food and Agriculture Organisation has been discussing the concept of "Farmers' Rights" for some time. "Farmers' Rights" values the knowledge system of local farming communities and recognises the value of the genetic enhancements they have developed within seeds, in particular (e.g. FAO 5/89). Farmers' Rights mean rights arising from the past, present and future contributions of farmers in conserving, improving, and making available plant genetic resources, particularly those in the centres of origin/diversity.

A definition of Farmer's Rights is now embodied in the International Undertaking on Plant Genetic Resources, currently under negotiation, now explicitly includes:
1. protection of traditional knowledge relevant to plant genetic resources for food and agriculture;
2. the right to equitably participate in sharing benefits arising from the utilization of plant genetic resources for food and agriculture;
3. the right to participate in making decisions, at the national level, on matters related to the conservation and sustainable use of plant genetic resources for food and agriculture.

Globally, there are two distinct knowledge systems within the formal sector of both private and public institutions, and within the informal sector of communities and individuals. The formal sector knowledge systems are codified, are recorded in writing and are defended through national and international law; the knowledge systems of the informal sector are often oral, are built on trust and are defended through the norms and practices of traditional institutions. The intellectual property (IP) of the former is recognised in law in industrialised countries and in the industrial sectors of developing countries. The latter has weak jurisprudence in its defence: there are no mechanisms to implement legislation and, in most cases, no legislation has yet been enacted, despite ratification of a number of international agreements, such as the Convention on Biological Diversity (CBD). It is left to individual governments to develop legislation that will ensure the protection of informal knowledge and the equitable sharing of benefits from its use.

National approaches:

The potential conflict between the two knowledge systems does need to be recognised and social, technical and legal systems of protection for biological resources in the public domain and those used by, and for the benefit of, the majority need to be developed accordingly.

Intellectual property rights (IPRs) are the rights given to persons over the creations of their minds – their intellectual property (IP). They are granted by a state authority for certain products of intellectual effort and ingenuity. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time. There has been much debate over the suitability of patents and other forms of intellectual property rights (IPRs) for the protection of plant genetic resources for food and agriculture. For example. the Crucible Group in their first report ***"People, Plants and Patents"***, included reflections on the inappropriateness of IP systems that risk the well-being of their peoples or that jeopardise the biological diversity within their borders. They also noted that there were likely to be conflict between IP proposals and other initiatives for plant genetic resources conservation and exchange:

Whatever the arguments may have been, there is now an overwhelming pressure on all WTO Members, through TRIPs Article 27.3(b) to consider applying IPRs to living material, and an obligation to apply them to plant varieties. In responding to this, countries have to weigh the balance of rights between industrial innovators, often not from the country concerned, and the rights of local communities, farmers, indigenous peoples and consumers within the country.

Community Rights

As Darrell Posey points out in ***"Beyond Intellectual Property",*** IPR laws are generally inappropriate and inadequate for defending the rights and resources of local communities and indigenous peoples. Traditional community knowledge is usually shared and the holders of restricted knowledge in communities probably do not have the right to commercialise it for personal gain. There are thus a number of models that are emerging to help people develop the basis of future legal systems to protect their knowledge and resources. These rights embody both biological and cultural rights and thus may go beyond other ***sui generis*** models (i.e. rights or legally recognised systems that are adapted to the particular needs of a country or community), which concentrate only on the biological resource (Posey and Dutfield, 1996).

Community rights may incorporate rights to manage some aspects of self-governance, natural resource management and economic livelihoods, including control over biodiversity, local knowledge, innovations and practices as required by the CBD.

The movement to set up community registers of biodiversity to thwart misappropriation and initiatives to implement a moratorium on bioprospecting are evidence of concern at community level, in the absence of adequate protection (see box, page x).. Farmers' Rights should also be considered within this bundle of rights and, importantly, need to be seen as complementary to, rather than in conflict with, other forms of community or indigenous peoples' rights.

Some of these rights are embodied in the CBD, especially Article 8(j), as well as in the FAO Farmers' Rights resolution 5/89, but these have yet to be enacted in national laws in most countries though there are a number of models under consideration (see Posey and Dutfield, 1996). The African Union (AU) has developed draft community rights legislation and some countries, including India and Malaysia as well as Andean Pact countries, have developed legislation that protects certain aspects of community rights.

The development of such codes of ***sui generis*** rights, recognised by trading partners, are seen by some countries as being a preferable alternative to the TRIPs Agreement with respect to biological resources, indigenous, local and community knowledge and locally controllable productive resources.

TOOLS

- IPGRI. 1999. Key questions for decision-makers. Protection of plant varieties under the WTO Agreement of Trade-related aspects of intellectual property rights. Decision Tools, October 1999, International Plant Genetic Resources Institute, Rome, Italy.

Principle 5: NBSAP planning needs to take account of the fact that different ecologic and socio-economic differences between farmers make it easier for some to manage biodiversity than others and that these difference are widening. In addition, diversity produced by farmers may not be maintained as their socio-economic circumstances change and thus new instruments for conservation may be used.

The following discussion borrows heavily from the text of the expert review on landscape level diversity , commissioned from H. Brookfield.

BEST PRACTICES

Assess the differences and explain them.
Develop specific policies for specific groups; including payment for ecological services
Link poverty alleviation plans with biodiversity plans

The layout of farms, the rotation of their land-use stages and field types, are all determined by those who manage the farms and the biological landscape within which farms operate. This is dynamic. Farmers are quick to respond to signals which demand variation in their strategies of resource mobilization. One aspect is of particular importance: the differential ability of farmers to manage their resources effectively. Farmers differ both in the amount of land and resources that they can use, and in their skills of management. The result is a patchwork of different outcomes for biodiversity.

Farmers managing good soils, and disposing of adequate resources of labour and other inputs, have an easier time in developing effective management of their soils than do poor farmers working only poorer soils. Increasing population density and evolving commercialization of production have the effects that resources become concentrated in the hands of a minority of more affluent farmers. In some areas, for example a high-density area of western Kenya, there is now a marked differentiation between a minority of affluent farmers who are able to invest in the good management of their soils and biodiversity and a majority now reduced to working very small farms. The latter cannot produce much of their own food, and depend so heavily on external employment that they are scarcely able to farm at all (Crowley and Carter 2000). No single strategy applicable to all farmers can be effective in the face of such differentiation.

The market has increasingly become the dominant force in farmers' decision-making. Farmers such as the Kofyar in northern Nigeria have not only given up most aspects of an intensive subsistence-based system developed over centuries on the Jos plateau but, in moving onto the plains, they have also shifted to market production as their principal enterprise. Yam cultivation for the urban markets absorbed more than a third of their total labour inputs in the 1980s (Stone 1997). In the West Africa case study written for this project, Gyasi and Enu-Kwesi describe in some detail the shift in production patterns made by the enterprising and adaptable people of southeastern Ghana. Having been major innovators for the export market in the late 19th and early 20th centuries, they responded to disease problems and market instability by shifting their activities to production for the national urban market in the second half of the 20th century. They continue to respond to the signals from that market.

The dynamism of farmers' practices has a large literature, the modern beginning of which was Richards (1985). Recently, Brookfield (2001) has described and discussed over 20 modern case studies, from the literature and field work, in which a high degree of adaptability is demonstrated.

Farmer adaptability has also been documented by the United Nations University Project on People, Land Management and Environmental Change (PLEC). Working since 1997 in almost 30 'demonstration sites', the PLEC project shows how agrodiversity not only supports global objectives toward conserving biodiversity, but also supports human needs and development. From some of its areas has come the important finding that sound management of biodiversity, both agrobiodiversity and managed forest biodiversity, can be profitable to farmers. PLEC works with the most skilled, or 'expert' farmers, in devising ways of using natural resources that combine superior production with enhancement of biological diversity. Successful farmers in turn train other farmers. Work is at different levels of farm intensification. As one example among many, PLEC scientists in northern Ghana are working with local farmers to conserve ***Oryza glaberrima***, the indigenous African rice. Farmers have traditionally relied on a diversity of varieties of this rice for food and livelihood security in face of difficult water availability and ecological change. The local group of PLEC scientists, and their farmer collaborators, are experimenting with ten varieties.

An important PLEC innovation has been the formation of a new kind of farmers' associations, both to manage demonstration activities and to form bridges between farmers, scientists and the authorities. These associations have been formed in most PLEC areas, and are working effectively in coordinating conservation with development at the local level. The project supports them in a number of ways, principally with material assistance rather than money. Several of the associations have organized income-earning activities among their members, especially in creating value from biodiversity. With these sources of income, they are able to plan and conduct new activities. By degrees, they are also becoming associated with other projects and with NGOs, thus facilitating the mobilization of support. The backing of the scientists has been very important in their formation, but increasingly the more successful of these associations are taking charge of their own affairs.

Farming systems, even those described as 'traditional', do not remain constant. Indeed, they can change very quickly, adapting to new circumstances, disasters and, in particular, opportunities. Although some farmers now regret the loss of formerly-widespread landraces, a great many eagerly adopted the products of modern plant breeding during the 'green revolution' years, and many continue to do so.

TOOLS

- Farmers' associations: It is not easy to specify tools for agrobiodiversity maintenance at landscape level, as the main requirement is the formation of groups of farmers able and willing to cooperate in agroecosystem management in whole communities and over areas of sub-regional extent. Moreover, the necessary scientific support has to be provided where it is not already present. The Australian landcare model could be used in participation with NGOs or Universities, and the PLEC farmers' association model can be employed if the necessary external support is forthcoming from agricultural and other research centres. The farmers' association model (a variant of the Community-based organization, or CBO) is as close as it is possible to get in many developing countries to the landcare model, and it can be an important tool for conservation in harmony with the improvement of livelihood security.

- The United Nations University Project on People, Land Management and Environmental Change (PLEC), since 1998 supported by the Global Environmental Facility, is another networking organization that brings together the efforts of more than 200 scientists and almost 3,000 farmers in twelve developing countrie: Brazil, China, Ghana, Guinea, Jamaica, Kenya, Mexico, Papua New Guinea, Peru, Tanzania, Thailand and Uganda.PLEC is specifically devoted to developing sustainable and participatory approaches to conservation, especially of biodiversity, within small farmers' agricultural systems.

PLEC produces a twice-yearly periodical, including numerous articles by its members, called *PLEC News and Views*; 18 issues have now appeared since 1993. One of the project's main objectives is to influence agricultural and conservationist policy in appreciating the value of indigenous land-use systems which have withstood all the tests of population growth, economic and environmental change.

http://www.unu.edu/env/plec/index.htm

List of Acronyms

AIA	advance informed agreement
BPSP	Biodiversity Planning Support Program
CBD	Convention on Biological Diversity
CBG/CBOs	Community based groups/community based organizations
DAD-IS	Domestic Animal Diversity Information System
FAO	Food and Agriculture Organisation
GEF	Global Environment Facility
GM	genetically-modified
GTZ	(Deutsche) Gesellschaft für Technische Zusammenarbeit
IFOAM	International Federation of Organic Agriculture Movements
IFPRI	International Food Policy Research Institute
ILEIA	Information on Low External Input and Sustainable Agriculture
IPGRI	International Plant Genetics Resources Institute
IPR	Intellectual property rights
ISFM	Integrated Soil Fertility Management
ISNAR	International Service for National Agricultural Research
ITDG	Intermediate Technology Development Group
IU	International Undertaking on Plant Genetic Resources
IUCN	International Union for the Conservation of Nature and Natural Resources
LEISA	Low External Input and Sustainable Agriculture
NBSAP	National Biodiversity Strategy and Action Plan
NGO	non-governmental organisation
PLEC	People, Land Management and Environmental Change
TRIPs	Trade-Related aspects of Intellectual Property
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WCMC	World Conservation Monitoring Centre
WTO	World Trade Organisation

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