Governance for a Sustainable Future. III: Managing Biodiversity for Food Security

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Report of the Commission on Genetic Diversity in Relation to Food Crops

III

Managing Diversity for Food Security

The Commission on Genetic Diversity in Relation to Food Crops

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The World Humanity Action Trust

CONTENTS

EXECUTIVE SUMMARY

The Commission on Genetic Diversity in Relation to Food Crops has focused on what is arguably the most important aspect of conserving and using genetic diversity: to ensure that genetic materials are readily available and used to sustain efforts to increase agricultural productivity and provide food security.

Historically, and especially since the 1960s, science has responded to threats of famine and the challenge of meeting the food needs of increasing populations largely through seeking to expand the production of staple foods and through other productivity-related agricultural research. However, the Commission notes that new efforts are needed in agricultural research as a result of a slowing in the yield growth of the world's food staples over the past decade and a half, a gradual decline in water availability for agriculture and other imperatives such as the urgent need to address interrelated issues of plant breeding, environmental sustainability and employment, as well as mitigating the potential effects of climate change. Crop genetic diversity is essential to the success of efforts to meet these challenges.

While focusing on agricultural genetic resources, needed both now and in the future, the Commission highlights the fact that they are only part of the overall wide spectrum of biodiversity which international efforts are attempting to conserve for the benefit of humankind. As a result, there is a great deal of confusion about the mechanisms and systems needed to conserve and use them, and this is nowhere more apparent than in the governance framework. The irreplaceable loss of genetic diversity worldwide has continued unabated while conflicting international fora have continued to debate what should be done to preserve it for the use of future generations, in a world which will hopefully be more environmentally conscious and where development will be sustainable.

Conflicts are inevitable given the range of international conventions and other instruments. On the one hand, the 1993 Convention on Biological Diversity (CBD) provides a framework for dealing with all biodiversity, recognising that it is subject to the jurisdiction of states which have a sovereign right to regulate access to it and to set the terms under which such access will be granted. On the other hand, the 1983 FAO International Undertaking on Genetic Resources for Food and Agriculture (IU), while recognising national sovereignty over genetic resources, provides for them to be exchanged openly and with a minimum of restrictions. Eight years of discussion in the FAO Commission has still not reconciled the two positions, although there is hope that this will occur. This one example of lack of agreement is further complicated by the fact that several other international instruments affect concerted action for the common good: one in particular is related to actions of the WTO. In this respect there is some evidence that market-led development may have negative effects on efforts to reduce global malnutrition and to increase production of food in developing countries, or may enhance the diversion of staple products from food to animal feed, and even enhance the decline in public-sector research. Such effects impinge on the patterns of use of genetic resources and even on the full appreciation that they are essential for food security.

Against this extremely complex background—little appreciated or understood by most administrators, law makers or the general public—the Commission makes a number of recommendations which could (1) improve the governance, (2) reinforce public funding for conservation, (3) promote incentives for the private sector to become a partner in the efforts and (4) help improve and make more effective the use of genetic diversity.

Governance

Due to such conflicts and the lack of coherence across the variety of international instruments, there needs to be a better process for coordination. Rather than press for radical change in existing instruments or organisations administering them, the Commission feels that the establishment of wider consultative processes could better lead to improved coordination of the global systems governing the conservation and use of genetic diversity for food and agriculture.

Wider consultation is needed at local, national and international levels. In addition, the Commission recommends that a specialised, independent panel of scientists be established to conduct, contract or referee authoritative studies which will help the decision-making bodies of the international conventions or other instruments, The report provides suggestions as to the composition and tasks of proposed consultative councils which could enhance consultation at national, regional and international levels.

Public Funding of Conservation

The funding of the international crop germplasm collections (including both seed banks and living collections as plants or tissue cultures) in the long term has not been adequately addressed even though they have always been considered a public good and funded as such in an ad hoc way. The Commission further notes the overall lack of attention, coordination and secure support to the *in situ* conservation of crop diversity in farmers' fields and the wider *in situ* conservation of ecosystems which are sources of diversity for use and/or are actually used by local communities.

The Commission recommends action by UN agencies and governments as follows:

(1) The FAO Commission on Genetic Resources for Food and Agriculture, the Global Environment Facility (GEF) and the Secretariat of the CBD should develop a mechanism to raise the level of international investment in genetic conservation for agriculture;
(2) Governments should reverse the decline in bilateral and multilateral aid flows to international and national genetic conservation activities because of the importance of investing in global food security;
(3) Governments should increase direct public investment in national genetic conservation activities.

Incentives to the Private Sector

Whereas the role of the private sector is increasing under the trends of privatisation and globalisation, on the whole private companies do not see themselves as having a responsibility to conserve genetic resources. Nonetheless, there are major opportunities for governments to engage farmers along with biotechnology and other companies in conservation and use through incentives including tax and subsidy regimes, the removal of perverse incentives and the development of a well thought-out policy environment for private farmers, companies and consumers.

The recommendations are wide ranging and include

(1) The need for governments to assess the incentive effects of tax, price and property right regimes necessary for signatories to the CBD to implement Article ii which requires the contracting parties to establish a system of incentives for the sustainable use of biodiversity;
(2) The need for the reform of taxes/subsidies and the development of rural credit facilities to encourage in situ *conservation and the need to develop methodology for sharing of benefits with primary conservers and holders of traditional knowledge;*
(3) The development of policies and incentives for private companies so that they can encourage genetic conservation and develop voluntary codes of conduct;
(4) The need for the provision of information to consumers to increase awareness of the need to conserve biodiversity and so that consumers can become stakeholders in policy development concerning agrobiodiversity, food security and sustainable development.

Effective Use of Genetic Diversity

Effective use cannot be separated from conservation activities. Nonetheless, the Commission notes a number of trends affecting use. For instance, plant breeding is increasingly privatised around the world. However, it is not widely recognised that prebreeding, as a stage in plant enhancement (which has always been mainly a public responsibility), requires continued public-sector involvement, especially in areas where private plant breeding is not commercially profitable or where there is insufficient market development to attract private breeders.

Modern plant breeding is increasingly using biotechnology and gene information, from functional genomics and molecular markers, and this raises the question of genetically modified (GM) crops. The private sector is likely to place more emphasis on developing GM organisms (GMOs) but the public sector also uses gene information. The Commission notes that GM crops will almost certainly assist efforts to reach world food production targets; they will also be valuable in improving yield potentials. Negative attitudes to them in developed countries may well hinder or delay the development of GM crops for poorer countries despite the opportunities.

These evolving scenarios related to use led the Commission to propose a range of actions at both government and international levels. The Commission recommends:

(1) That the continued availability (and sharing of benefits) of genetic resources is best served by a multilateral system through a revision of the IU. This needs to be harmonised with the prior informed consent and equitable benefit-sharing provisions of the legally binding CBD as soon as possible;
(2) Because conservation is long-term, as is use of the diversity conserved, governments should develop a long-term agricultural strategy whereby use of diversity will continue to satisfy nutritional needs and assure food and income security;
(3) Policies should recognise that farmers need support, encouragement and social recognition to safeguard and sustainably manage genetic resources;
(4) Policies need to recognise the gender dimensions of biodiversity management, especially since in many parts of the world women play a major role in conserving and using biodiversity;
(5) National and international programmes should involve participatory plant breeding with farmers which aims to promote enhanced productivity and at the same time ensure survival of genetic diversity.

The report that follows provides more details of the Commission's recommendations, and also a series of appendices, which provide summaries of particular issues which the Commission had to clarify before reaching a consensus on them.

1. Introduction

While the world has begun to take the problem of loss of biodiversity seriously, genetic diversity in the world's farmlands has been neglected. The link between genetic diversity and the need for its conservation to sustain agriculture should be much more widely appreciated by policy makers and the general public. Genetic diversity is needed for use in ensuring global food supplies and food security.

The samples of genetic diversity, termed genetic resources, can improve productivity and yield growth, provide resistances to pests and diseases and be used to adapt food crops to a range of environmental stresses. The resources support efforts to diversify agriculture to include nonfood crops such as fibre and other industrial crops which improve income security. Resources can also enhance the productivity of farmlands by protecting soils, water supplies and pollinators. They have huge potential to protect the resilience of agriculture in the face of changes in global environmental conditions, particularly global change as defined by the Geosphere–Biosphere Programme.

New technologies such as biotechnology, including genetic engineering, have opened up opportunities for moving genes between species and generating new genetic combinations, thereby enhancing the use of genetic diversity in plant breeding.

Plant breeding has to respond rapidly to provide food security for an ever-growing world population and to adapt to new needs such as climatic change. Such responses depend on genetic diversity both for increasing yields on the one hand and for the health of the environment on the other.

Despite downward revisions of UN projections of population growth, food supplies will have to grow at approximately 2% a year (see Box 1-1) over the next five decades simply to maintain current levels of nutrition. To improve nutrition levels of the more than 1 billion people living on less than US$1 a day, rates of agricultural productivity growth will have to be even higher in low-income countries.

Significant improvements in agricultural productivity in the past have been the result of intensification of agriculture and there is potential for further improvement. However, past efforts of intensification have accelerated the loss of biodiversity, particularly by the introduction of high-yielding crop varieties displacing traditional land races, despite the immense value of the newer varieties. Use of pesticides and fertilisers with the high-yielding varieties has resulted not only in reduced pests and diseases and increased productivity but also in the loss of other beneficial organisms, including wild and weedy relatives of crop plants. At the same time, expansion of cropland has led to the fragmentation and loss of a wide range of habitats which support such beneficial organisms. Species used to control invasive weeds and pests and wild relatives of crops have become increasingly threatened, in addition to the traditional crop genetic diversity being replaced by the new varieties. These developments have made farmers more susceptible to changes in market or environmental conditions.

While awareness of these issues is increasing, attempts to find solutions are made more difficult by failures of effective governance. Such failures have numerous consequences: for instance, market prices fail to signal the importance of genetic diversity in farmlands, agricultural subsidies have had perverse effects on farmers' choices, and farmers have been encouraged to ignore the environmental consequences of crop choices. Conservation of genetic resources has been an issue for governments and, for the most part, the energies of the private sector have not been enlisted in support of conservation.

Genetic conservation for agriculture is in the nature of a public good. Governments and intergovernmental

BOX 1-1. POPULATION AND FOOD SECURITY PROSPECTS

Human population has grown more since 1950 than in all the time humans have been on Earth. By 2020 the world's population is projected to increase by 32% to reach at least 7.5 billion.

To meet food demands, the world's farmers will need to produce 40% overall more grain in 2020, as well as other agricultural produce. Almost all of the increase in world food demand will take place in developing countries. To meet demands the bulk of the food will have to result from improvements in crop yields through plant breeding.

It is predicted that food insecurity and malnutrition will continue to be evident in 2020 and beyond. Improving both are international imperatives. Fostering food security and protecting natural resources are essential goals of sustainable development and this includes more focus on small-scale farmers.

Continued availability of genetic resources is a *sine qua non* in the efforts towards greater food security and new sustainable approaches to agriculture. (Data based on IFPRI Reports.)

organisations have consistently underinvested in it. Additionally, governmental and nongovernmental organisations (NGOs) have failed to coordinate their response to the challenge of linking agricultural development and biodiversity loss.

The legal and other international instruments which govern the conservation and use of biodiversity at present are administered by many intergovernmental agencies (see Appendix A). The major ones relating to agricultural genetic resources include the 1983 IU, currently nonbinding, administered by the FAO; the 1992 CBD, administered by the UN Environment Programme; the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) administered by the World Trade Organisation (WTO) and the 1978 (revised 1991) Convention of the International Union for the Protection of New Varieties of Plants (UPOV).

A number of other conventions have a bearing on biodiversity and, additionally, a number of programmes stemming from the conventions and agreements are directly related to aspects of governance. In particular, those central to agricultural genetic diversity include the FAO Global Plan of Action on Plant Genetic Resources for Food and Agriculture (which derives from Article 7.1 of the IU), the FAO International Network of *Ex situ* Collections which includes the genetic resources held in trust by the research centres of the Consultative Group on International Agricultural Research (CGIAR) and Agenda 21 (implementation monitored by the UN Commission on Sustainable Development) which includes a series of activities intended to improve the conservation of biological diversity, to encourage the use of genetic diversity in agriculture and to support the CBD. Box 1-2 shows the long list of conventions and agreements which have to be taken into account in overall governance.

This report addresses the deficiencies of governance that have contributed to a poor check on the loss of genetic diversity in agricultural systems. Its focus in on plant genetic diversity in agriculture but many of the principles discussed and

BOX 1-2. INTERNATIONAL AGREEMENTS AND PROGRAMMES RELEVANT TO GENETIC DIVERSITY

Food and Agriculture:

- International Undertaking on Plant Genetic Resources for Food and Agriculture (1983) (IU)
- Global Plan of Action for the Conservation and Sustainable Utilisation of Plant Genetic Resources for Food and Agriculture (1996)
- World Food Summit Plan of Action (1996)
- International Plant Protection Convention (1951)
- Material Transfer Agreements for Plant Germplasm, as agreed by the FAO Commission on Plant Genetic Resources (1993 and revisions)
- The Cartagena Protocol on Biosafety (of the CBD)

Natural Resources and Sustainable Development:

- Convention on Biological Diversity (1992) (CBD)
- Agenda 21: Programme of Action for Sustainable Development (1992)
- Convention on International Trade in Endangered Species of Wild Flora and Fauna (1973)
- Ramsar Convention on Wetlands of International Importance Especially as Wildfowl Habitats (1971, 1982)
- Convention Relative to the Preservation of Fauna and Flora in Their Natural State (1933)
- UNESCO Man and the Biosphere Programme (1971)
- International Tropical Timber Agreement (1983)
- Convention to Combat Desertification (1994)
- The Climate Convention, especially the Kyoto Protocol

Trade and Property Rights:

- World Trade Organisation: Trade Related Intellectual Property Rights Agreement (1996) (TRIPS)
- International Union for the Protection of New Varieties of Plants (1978, 1991) (UPOV)
- GATT Agreement on the Application of Sanitary and Phytosanitary Measures (1994)
- UNESCO/WIPO Model Provisions for National Laws for the Protection of Expressions of Folklore against Illicit Exploitations and other Prejudicial Actions
- Convention on the Means of Prohibiting the Illicit Import/Export and Transfer of Ownership of Cultural Property

recommendations would apply to biodiversity in forestry, fisheries and livestock farming. The Commission has found that addressing the international framework of governance alone would be insufficient to cause effective and needed changes. Accordingly, a series of wide-ranging recommendations are made to the international community and to governments which could lead to more effective conservation and use of genetic diversity.

2. Improving Coordination of Governance

Due to the variety of international instruments that address genetic conservation and use of genetic diversity in plant breeding, nature and natural resources conservation, sustainable development and trade, and other issues, it is evident that coherence does not exist. There are differences in interpretation and a lack of understanding of interdependent issues. Action taken under one instrument can lead to negative consequences on issues addressed and governed by another. For example, under the WTO regime, governments are unable to implement policies designed to conserve genetic resources wherever these can be seen as an infringement on free trade. As another example, the CBD makes genetic resources the sovereign property of states, yet the IU and the FAO International Network of *Ex situ* Collections (including materials held by CGIAR centres) promote a multilateral system with germplasm being freely available. A process of coordination across the governance system is urgently needed. This is an imperative because the genetic diversity within the food and agriculture sector continues to shrink. Accelerated use of these resources to ensure food security should not be hampered by interminable discussions of subsidiary bodies or negotiating groups.

Problems caused by lack of coherence at the level of global governance lead to confusion at the national level. Responses and actions stemming from a government signing up to a range of international agreements are only very rarely harmonised or integrated with wider environmental, economic and sustainable development initiatives.

There is also concern that the governing bodies of the international conventions and agreements frequently lack the independent scientific advice needed to make well informed decisions. This concern is especially apparent in areas that cut across the mandates of several distinct organisations.

2.1. Recommendations

In order to improve the coordination of governance we recommend that consultative bodies be established to harmonise the conflicting approaches of the various instruments administered by UN agencies. Four types of consultative bodies are recommended.

(1) The UN should form a consultative forum on biodiversity charged with harmonising conflicting approaches of the various instruments administered by UN agencies.

The forum could be under the auspices of the Commission on Sustainable Development and take a form similar to the UN Forum on Nutrition. The tasks of the forum would be to analyse and share information, to coordinate actions on biodiversity and to propose methods of resolving conflicts. Its mandate would include agricultural genetic resources. The agencies involved should include the FAO, UNEP, the UN Development Programme, the CBD Secretariat, the UN Industrial Development Organisation, UPOV, the WTO, UNESCO, the World Intellectual Property Organisation (WIPO), the World Bank (IBRD), and the GEF. Other leading international organisations such as CGIAR, the Global Forum for Agricultural Research, the World Conservation Union (IUCN) and the World Wide Fund for Nature (WWF) should be invited to participate as appropriate.

(2) National governments should establish consultative bodies, or standing interministerial consultative processes, charged with better coordinating the national input to international instruments to which the country is a party and with the development of more coherent national policy to meet obligations under such agreements.

The consultative body should focus on the conservation and sustainable and equitable use of biodiversity, and should not only help the creation of sectoral and cross-sectoral national policies and plans, but also monitor their implementation and consequent actions and oversee periodic inputs to international fora. The body might include governmental agencies which deal with environment, agriculture, forestry, water resources, science, education, industry, commerce and tourism as well as finance in view of the need to harmonise country assistance strategies in this area of concern. Each ministry might be advised by formal bodies such as research councils or other institutions, but the separation of functions among different agencies leads to a lack of policy coherence and weakens a country's position in international fora. NGOs, such as farmers' and/or women's organisations, private industry, civil society as well as media (electronic and printed) representatives and consumer groups should be invited to participate as appropriate. It is essential that the body is created to best suit the individual country's infrastructure and degree of centralisation or decentralisation of coordination and implementation.

Those countries which have already established consultative mechanisms to facilitate the development of appropriate policies and plans in response to an individual international instrument (for example, for national biodiversity planning to support implementation of the CBD or for national plant genetic resources for food and agriculture to support the IU or FAO Global Plan of Action) will need to broaden these to collectively address the interests of all stakeholders and articulate national genetic diversity needs and objectives, as well as addressing legal and institutional issues and the costs of different courses of action. Policy coherence leads to a more balanced decision-making process; the need for it is applicable to developed as well as developing countries.

(3) Nations should form regional consultative bodies to improve co-operation in biodiversity management where these do not already exist (or are currently ineffective) and where there are shared interests in conservation and use of genetic diversity.

Regional consultative bodies as well as regional programmes or networks can complement national activities and enhance cost effectiveness. Planning at the regional level can also help smaller or poorer countries and result in more effective and equitable coordination.

(4) A specialised, nonpolitical panel of scientists should be created to help decision making by the governing bodies of the international instruments.

The International Council of Scientific Unions, the Third World Academy of Sciences and the Inter Academy Panel should be invited, in consultation with the major relevant UN agencies, to form such a panel. The panel should be charged with conducting, contracting or refereeing authoritative studies on issues germane to implementing the agreements to ensure conservation and use of biodiversity, particularly genetic diversity for food and agriculture. There are numerous areas which lack such studies: important ones for urgent consideration are the issue of trade-off between increasing productivity and conserving biological diversity, the impact of intellectual property rights on the conservation and use of genetic resources and the impact of international agreements on access to genetic resources for use in achieving the hunger elimination targets of the 1996 World Food Summit. Members of the panel should serve in their individual capacities and not be nominated as political appointees, and the panel should have the freedom to contract the best scientific organisations or individuals.

2.2. Funding Improved Coordination of Governance

The recommendations on better coordination, if implemented, should not result in the need for large amounts of additional funding. The Commission's view is that strengthening the coordination at the level of existing international agencies is a standard responsibility of these organisations. Improved coordination and the resulting elimination of overlap in initiatives and programmes could lead to a decrease in expenditure on areas where poor coordination has previously encouraged proliferation of conflicting work.

3. Public Funding of Conservation

Conservation of crop genetic diversity for use in food production and for food security requires that germplasm be conserved using a range of complementary methods. These include conservation *in situ*, both on-farm and in wild ecosystems, and in *ex situ* collections. Wild ecosystems with low human pressure are of interest because they contain wild species related to crop plants which can be used in breeding or species which are undomesticated but are used for diverse purposes by humans.

The *ex situ* collections contain samples of germplasm of a wide spectrum of diversity of crop genepools and range from international collections to regional, national and local collections. The majority of collections are in the agricultural domain but a number of botanical gardens also maintain important *ex situ* materials. For *ex situ* conservation a range of techniques are employed to store the materials as seed, *in vitro* cultures or plants, but the bulk of the major collections of crop materials are stored as seed (see Appendix B).

In situ conservation (see Appendix C) of crop diversity yields benefits to society that cannot always be utilised by individual farmers or companies. For this reason it depends on public funding. At present, there is no guaranteed long-term funding for these conservation efforts, nor for the *ex situ* collections.

International *ex situ* collections have been funded through the mobilisation of international aid resources and now fall within the framework established by the FAO's IU and its agreements with the CGIAR centres to hold the genetic resources vital to food security in a multilateral system. Currently these collections require about US$7 million for annual maintenance, and collectively about US$20 million over five years to upgrade them to the best standards. Sustained funding for their future maintenance has not yet been secured.

The international collections form a major part of the FAO Global Plan of Action for the Sustainable Use of Plant Genetic Resources in Agriculture, which aims to translate the IU into practice. It appears unlikely that this will yield sufficient additional resources, and funding provision remains an open question.

The regional and national *ex situ* collections, and much of the *in situ* conservation, are the responsibilities of national governments, supplemented by project funds made available under the GEF or bilateral or multilateral aid. Project funds are limited in time and aid flows are not only ad hoc but they are also declining. International debt relief will help, but there is a clear and substantial need for new and additional funding to safeguard these conservation efforts.

3.1. Recommendations

This Commission notes that action in funding is needed both by UN agencies and by governments working together to enhance the definition of a global system for conservation and use of genetic diversity. We recommend that

(1) The FAO Commission on Genetic Resources for Food and Agriculture (guiding the IU), the Secretariat of the CBD and the GEF should together develop a mechanism to raise the level of international investment in genetic conservation for agriculture;

(2) Governments should immediately reverse the decline in bilateral and multilateral aid flows to international and global agricultural genetic conservation efforts, recognising that such action would be an investment in global food security;

(3) Governments should increase direct public investments in national agricultural genetic conservation. This should include all complementary techniques including the conservation and use of genetic resources and habitats by local communities;

(4) Governments should undertake measures, where appropriate, to revitalise and strengthen the in situ *on-farm conservation traditions and practices of rural and tribal families.*

The Commission defines three priority areas for immediate action through the mobilisation of multilateral, bilateral and national investment: firstly, centres of agrobiodiversity which are currently under anthropogenic threat; secondly, the long-term funding and the long-term security of *ex situ* collections, including both seed and living plant collections; and thirdly, restoration of locally adapted materials.

4. Incentives to the Private Sector

In decentralised market economies crop genetic resources become increasingly held and used by private agents—including agribusiness, seed companies, plant breeding and other companies utilising biotechnology. The private sector plays an increasing role under the trends of privatisation and globalisation. An increasing proportion of plant genetic research and development activities is progressively privatised. The growth (and mergers) of multinational seed, pharmaceutical and biotechnology companies has increased the concentration of private research and development activity. This has major implications both for the conservation and use of crop genetic diversity and for the biodiversity of the supporting environment.

There is a need for plant breeding and genetic engineering activities to reflect not just the responsibilities of individual companies to their shareholders but also the more general responsibility to society. With rare exceptions, private companies do not see themselves as having a responsibility to conserve genetic resources. There is evidence that where germplasm collections are held by companies, the types of materials, in terms of the type of crops and the range of their wild species, land races, advanced land races and advanced cultivars, differ substantially from the types held in public collections.

Companies operating in the global market cannot be concerned with crops with small sales potential, such as those suited to highly localised niches. One outcome of this is the potential for the genetic homogenisation of global seed supplies, especially in the major food and industrial crops. Another outcome is less use of land races in plant breeding despite their great historical value in germplasm enhancement—and the considerable potential to incorporate desirable traits into local land races to improve their value.

The Commission recognises that successful conservation of genetic diversity in agriculture will have to enlist the support of the private sector. Under the governance framework, for example, Article 11 of the CBD requires governments to develop economic incentives to conserve biodiversity. Incentives include tax and subsidy regimes, but they also include the allocation of property rights to farmers and firms in land, water and other natural resources, and the security of those rights. In practical terms there are ways in which governments can engage farmers along with seed, agrochemical, biotechnology, pharmaceutical, food distribution and other companies in the conservation and use of genetic resources for agriculture.

Creation of economic incentives has to occur in a broad policy framework. In many cases incentives created by agricultural policies have had negative effects on genetic diversity. For instance, current rates of biodiversity loss in farmlands reflect the fact that farmers are not aware of many of the social costs of biodiversity loss or the benefits of conservation. Perverse effects include administered prices on agricultural markets and subsidies that encourage clearance of ever more marginal land for agricultural purposes and deforestation at excessive rates. Such effects are exacerbated by the credit constraints that face small farmers in most developing countries. Indeed, only 5% of farms in Africa and 15% in Asia and Latin America have access to formal credit.
It is estimated that global subsidies to biodiversity-degrading activities are currently in the region of US$700–800 billion,

and that non-OECD country subsidies to biodiversity-degrading activities are in the region of US$150 billion.

4.1. Recommendations

The Commission recognises that a wide range of actions are needed at the government level to affect government programmes, private farmers, companies and consumers. We recommend the following:

(1) National governments should assess the environmental impact of tax, price and property right regimes with a view to removing subsidies and incentives which lead to ecological suicide.

(2) For private farmers, governments should

- *reform agricultural taxes/subsidies to encourage conservation of land races and the habitats of wild species related to crops; in this respect, consideration might be given to differential land-use taxes*;
- *develop rural credit facilities and conditions to encourage investments in the conservation of genetic diversity; this might include the development of special banks or windows within existing banks to fund biodiversity conservation in agricultural areas;*
- *guarantee the security of land rights to encourage investment in conservation (by, for example, allowing land to be used as collateral) and*
- *develop a transparent and easily implementable method to reward the primary conservers of genetic resources in agriculture and holders of traditional knowledge about the specific attributes of plants. Box 4-1 illustrates an existing innovative procedure for the sharing of benefits.*

(3) For seed, biotechnology, pharmaceutical and other companies, governments should

- *develop incentives to encourage genetic conservation, including the terms on which access to genetic resources is negotiated;*
- *hypothecate taxes/royalties on genetic resources so that revenues raised should be committed to conservation (an example might include an agricultural tax that is used to create a community gene fund) and*
- *encourage voluntary codes of behaviour and agreements.*

Box 4-1 illustrates an example of an agreement related to plant products, especially pharmaceuticals. These could include, for example, the revelation of the sources of genes that enter into the making of commercially successful varieties.

(4) For consumers, governments should

- *provide information, where feasible, on the conservation status or links between goods produced and their genetic resources (certification or conservation labelling);*
- *disseminate information on biodiversity under threat in agricultural systems to enable consumers to make more informed choices and*
- *develop taxes on agricultural goods and services whose production involves environmental damage so that the damage is reflected.*

We also recommend that governments should, in order to fully inform about their decisions and actions, implement and report a set of natural resources accounts which would supplement existing national income accounts. The accounts should report depreciation in the natural assets of a country, including agricultural genetic resources.

BOX 4-1. BENEFIT SHARING—THE TBGRI MODEL

The Tropical Botanical Garden and Research Institute, Thiruvananthapuram, Kerala State, India, has developed an innovative procedure for the equitable sharing of benefits with the tribal families who discovered the antifatigue properties of the plant *Trichopus zeylanicus*.

Young members of the Kani tribe living in the Western Ghats region of Kerala drew the attention of Dr Pushpangadan, Dr Rajasekharan and their colleagues to the energy- and strength-giving properties of the fruits of this plant. The TBGRI scientists took steps to get the fruits chemically analysed as well as to get an antifatigue drug named Jeevani manufactured by an Ayurvedic pharmaceutical company.

The agreement between TBGRI and the company provides that 50% of the licence fee and a 2% royalty at exfactory sales price be paid to Kani tribal families. In addition, TBGRI arranged for the cultivation of the plant by 50 tribal families on the basis of a buy-back arrangement with the company. Thus, the tribal families not only benefit from their share of the licence fee and from royalty but also receive a steady annual income for domesticating the plant for commercial use.

Source: Dr P. Pushpangadan, Director, TBGRI (Personal communication).

5. Effective Use of Genetic Diversity

The links between conservation and the more effective use of genetic diversity are now widely recognised as a key to improving productivity and sustainability and in contributing to socio-economic development and food security. This recognition includes continued access to genetic resources for use in plant breeding contributing to productivity and yield growth. There is need for the crop improvement to contribute to reduced genetic vulnerability and less genetic loss, and there are needs for more equity in crop improvement approaches so that there is more sustainable development.

Despite Agenda 21 and the CBD, rapid globalisation of agricultural markets and seed supplies continues to lead to a reduction in genetic diversity. A most obvious example is the reduction in the range of land races used by farmers in developing countries and the reduced use of land races not only at the local farming level but also by the public and private sectors. The reduction in genetic diversity has been accelerated by the trend to privatisation of public plant breeding and seed production services in both developing and developed countries.

It is not widely recognised that the prebreeding stage in plant enhancement has always been a public responsibility and requires continued public-sector involvement, especially in areas where there is insufficient market development to attract private breeders. Private plant breeding tends to find public prebreeding inefficient and prefers introgression with early generation testing.

Modern plant breeding will increasingly employ biotechnology, and GM crops are likely to assist in reaching needed food production targets, by improving yield potential and yield stability. The development and adoption of GM crops involves qualitatively different ethical, equity and safety issues than do traditional plant breeding procedures. (A discussion of ethical principles can be found in Appendix D). In an era which needs to produce more staples and other agricultural commodities under conditions of shrinking per capita arable land and irrigation, a transition from the Green Revolution to the Gene Revolution based on rapid strides made in molecular genetics holds promise—especially when principles of ecological, economic and social sustainability are applied: see Box 5-1 for an example of promising transgenic work.

The ethical and safety issues of biotechnology are complicated by issues of proprietary science. There are fears that proprietary science can lead to monopolistic control over food security and fears that GM technologies can have ramifying ecological effects, cause genetic pollution and affect biodiversity, and have other risks.

The recent discussions leading to a Biosafety Protocol under the CBD were less than harmonious and were complicated by parallel discussions reviewing the TRIPS Article 27:3(b) dealing with food, farming and agricultural biodiversity.

Governments have a most important role to play in regulating biotechnology through specific regulations on biosafety, working with appropriate intellectual property rights and through antitrust legislation to counter excessive monopolisation by industry. Only through such concerted action will the results of biotechnology be used to help alleviate food insecurity, malnutrition and reduce poverty. Negotiations in early 2000 on the Biosafety Protocol now offer hope for some resolution of the confrontation which has been emerging between scientists and critics concerning GM crops.

The Commission recognises the need for national governments to set up procedures for the analysis of the risks and net benefits of new technologies using genetic diversity that will inspire public confidence. We suggest that the independent panel of scientists recommended in Section 2

BOX 5-1. DESIGNER POTATO FOR BETTER NUTRITION

Improvement of the nutritive value of crop plants, in particular the amino acid composition, has been a major long-term goal of agricultural scientists. Towards this end, a gene (*AmAl*) that encodes for an albumin with a well balanced amino acid composition and high levels of the essential amino acids was isolated from mature seeds of *Amaranthus hypochondriacus*. The amino acid composition of this protein is comparable to the WHO recommended values for optimum human nutrition (Raina and Datta, 1992). Potato is the most important noncereal food crop and ranks fourth in terms of total global food production, also being used as animal feed and as raw material for the manufacture of starch, alcohol and other food products. In an attempt to improve the nutritive value of potato, the *AmAl* gene was suitably introduced and expressed in constitutive (*pSB8*) as well as tuber-specific (*pSB8G*) manner. The expression of *AmAl* led to a striking increase in the growth and production of tubers in transgenic populations, as also of the total protein content, with an increase in most essential amino acids (Chakraborty *et al., 2000*). The results well document, apart from the successful nutritional improvement of potato tubers, the feasibility of genetically modifying other crop plants with novel seed protein composition.

could play a major role in promoting understanding of the proper application of GM crop research to help the poor and in promoting a public environment for its development.

Prebreeding, already mentioned, can also be accelerated by biotechnology. Box 5-2 describes innovative research on prebreeding which goes well beyond the typical wide crossing between a crop and its wild relatives. In this respect the Commission, whilst recognising the need for public agricultural research to continue to take responsibility in this area, also recognises the need for policy to be developed to back partnerships between the public and private sector and the relevant CGIAR centres. These partnerships need to be innovative and range from participatory plant breeding with farmers to including gender dimensions supporting farmers in managing genetic diversity in agriculture.

In terms of governance, continued availability of genetic resources for use for food and agriculture has to be assured at the global level and governance also has to ensure that innovative partnerships receive support through access to materials. Additionally, public-sector involvement in breeding is essential to obtain public benefits (*a*) where private plant breeding is not commercially profitable, especially in marginal areas, (*b*) for orphan, and under-utilised crops and varieties where there is insufficient market development to attract private breeders, (*c*) to undertake activities such as prebreeding and (*d*) for participatory plant breeding with farmers where this will not occur without public-sector involvement.

5.1. Recommendations

At the global level, the Commission recommends that the continued availability of genetic resources for use in agriculture is best served by the multilateral systems through the proposed revised IU. It is vital that the negotiations to revise and harmonise this with the legally binding CBD framework be speedily concluded. A revised IU will provide a multilateral system of exchange in the case of crops of great importance to global and national food security and could be included in the CBD as a separate protocol. We recognise that many of the benefits arising from conservation and effective

BOX 5-2. RESEARCH TO MEET THE CHALLENGE OF A POTENTIAL RISE IN SEA LEVEL

Coastal ecosystems suffer from the twin problems of increasing population pressure and low crop productivity due to abiotic factors such as high salinity. In coming years these problems will be more acute, primarily due to increasing salinity as a result of the rise in sea level as a result of global warming. Immediate attention and research programmes are needed to mitigate or address these problems. In this context, as a part of its Anticipatory Research Programme, the M. S. Swaminathan Research Foundation (MSSRF), Chennai, India has initiated a major study on mangroves as a prelude to developing a conservation strategy for the depleting mangrove genetic resources and also to exploit the genetic potential of this specialised group of plant species in mitigating the problem of coastal salinity.

Mangroves are tropical and subtropical estuarine plant species with immense ecological, economical and genetic potential for sustainable development. Despite their economic and ecological potentiality, these species have so far received little or no attention. Studies on mangroves, particularly from the genetic standpoint, are meagre. Genetic analysis based on molecular markers was initiated at the MSSRF to gain an insight into the nature and extent of species differentiation within and between the mangrove species. The information derived from the studies on genetic diversity, genetic content and pattern of variation at molecular level have helped to provide unambiguous information on the species identity and phylogenetic and evolutionary relationships. It has helped to identify priority species and sites for conservation and in designing conservation strategy suited to a particular species for *in situ* conservation.

Isolation of genes conferring salinity tolerance in mangroves is being carried out to provide characterised prebreeding material to the grass-root-level breeders for developing location-specific crop varieties that could offer tolerance to coastal salinity. One such gene, *Betaine Aldehyde Dehydrogenase* (*BADH*) cloned from one of the most salt-tolerant mangrove species, *Avicennia marina,* is currently being evaluated in transgenic tobacco and *Brassica* systems for the efficiency and efficacy for salinity tolerance. *BADH* converts *betaine aldehyde* to *glycine betaine*. *Glycine betaine* is an effective compatible solute and its accumulation confers salinity tolerance in plants. The transgenic tobacco and *Brassica* overexpressing the *BADH* from *Avicennia* conferred salinity tolerance up to 250 mM NaCl with external supply of *betaine aldehyde*. Isolation of a gene which can convert the ubiquitous *choline* into *betaine aldehyde* is being actively pursued. Other genes with immense implications on stress resistance isolated and characterised from the mangrove species include *Catalase* (*CAT*), *Superoxide Dismutase* (*SOD*), *Glyoxalase* and *Sodium Hydrogen Antiporter*. These genes are being evaluated for their performance in transgenic systems. Stress tolerance is a multigenic trait involving many enzymes and products. Work on identifying and isolating the genes encoding these enzymes which are part of the biosynthetic pathways is also being carried out to help build durable genetic tolerance to various abiotic stresses, and in particular to salinity.

use are international, and should be distributed via the multilateral system.

Countries are generally agreed on the need for a multilateral framework to facilitate access to genetic resources of the main crops for which countries are highly interdependent, and which are the basis for food security. The multilateral framework also allows for benefit sharing to enable continued progress in plant breeding and to benefit farmers through the recognition of their role in developing the genetic materials over time. We can look forward to progress as the FAO Global Plan of Action on Plant Genetic Resources for Food and Agriculture, agreed by governments in 1996, becomes speedily implemented, and as the governance framework becomes clarified (as recommended in Section 2).

The Commission notes the long-term nature of conservation and so too the use of the diversity. Accordingly, we recommend that governments should develop long-term agricultural strategies at the national level in order to satisfy nutritional needs and to assure food and income security. Such strategies have to include the promotion of an appropriate level of diversity in agriculture and its genetic base and may well include research and development of currently nonutilised and under-utilised crops (including their *in situ* conservation).

The Commission also notes the need for strategies to be proactive in relation to changing needs. For instance, in order to adapt to climate change, plant breeding is likely to require breeding strategies to increase tolerance to climate variability and/or modifying cropping systems to best use, say, increasingly scarce water. Hence, the plant breeding needs have to be balanced with changing strategies for land use, and agricultural production systems. Mitigation of climate change involves agricultural practices and breeding for more productive pastures or agroforestry systems and rehabilitation of degraded lands.

In developing policies, we recommend the following:

(1) Governments should recognise that farmers need support, encouragement, social recognition and economic reward to safeguard, manage and sustainably use genetic resources that may be threatened by undue economic pressures, or when there are failures to obtain market returns.

This recommendation strengthens one already made in Section 3 which recognises the need for public funding for on-farm conservation due to the major role in sustainable agriculture. At the moment, farmers are conserving genetic diversity for the public good at personal cost. Despite the role in food security, the primary conservers remain poor, while those who utilise their knowledge become rich. Policies need to be in place to support farm management of genetic diversity, for instance by making suitable new germplasm available through a national genetic resources system, or germplasm repatriated from *ex situ* collections where it has been lost locally.

(2) It is also important to recognise the gender dimension of biodiversity management. In many countries, women are the primary selectors and savers of genetic diversity; their activities need policy support.

We recommend further that governments and international programmes involved with use of genetic resources introduce

BOX 5-3. INTERNATIONAL COLLABORATIVE BIODIVERSITY GROUP, PERU

In September 1996 representatives of the Aguaruna People of the Peruvian Amazon signed a bioprospecting agreement with the parties of the International Collaborative Biodiversity Group. This project involves Searle & Co. (the pharmaceutical arm of the Monsanto Corporation), Washington University, the Peruvian University of Caytano Heredia and the Natural History Museum of the University of San Marcos. The project is sponsored by the National Institute of Health, the National Science Foundation, the National Cancer Institute and the US Agency for International Development. The aim of the programme is to '…address biodiversity conservation and the promotion of sustained economic activity through drug discovery from natural products'.

After protracted negotiations, it was possible to devise a strategy to achieve the Aguarunas' objectives of equitable benefit sharing, protection of control over use of natural resources, prevention of patenting of life forms, etc. Know-how licensing for the protection of Aguaruna knowledge was first proposed in 1994 by Bendon Tobin (Personal communication) with three principal benefits: (a) control of use to remain in the hands of the local custodians, (b) opportunity for benefits through R&D activities, including advance royalty payments and (c) protection of information already within the public domain.

The other part of the project focuses on medicinal plants based on indigenous knowledge. Knowledge about the value of resources to be collected is thus available in the public domain. The royalties will be shared equally by Washington University, the University of Caytano Heredia, the Museum and the indigenous people.

participatory plant breeding with farmers to promote enhanced productivity and ensure survival of genetic diversity, especially in marginal areas. Innovative partnerships should use all appropriate techniques, including biotechnology, and many will require specifically negotiated terms as in the case of bioprospecting (see Box 5-3).

6. Postscript

Throughout the deliberations of the Commission it was recognised that as the world faces unprecedented challenges in the twenty-first century—marked by globalisation, major changes in international institutional and economic arrangements, and needed increases in food supplies and food security—the role of science and technology for development is never more apparent. Also, today the food security challenge is as much the affordability of food as its availability in the market.

Major advances in science and technology affecting food supplies and nutrition will require more effective conservation and use of genetic diversity. Such advances include the creation of novel genetic combinations and new approaches leading to higher productivity without adverse effects on the natural resource base, in conjunction with new governance systems which can incorporate ethical and equity principles and the sustainable use of diversity.

Underpinning the better governance of genetic diversity is the continued generation of scientific and technical knowledge, the promotion and use of this knowledge for development, and the dissemination of information through education at all levels. While confident in recommending enhanced co-operation in institutional arrangements and a greater involvement of civil society in decision making, the Commission noted that education needs are extremely wide-ranging. It was felt that these are best addressed by those institutions involved with governance of genetic diversity and by nations who, in order to comply with their various obligations under international agreements, require greater investment in research and development, in the generation and communication of scientific and technical knowledge, and in the promotion of enlightened policies.

There are great challenges to international organisations to build new and effective knowledge systems so that there are positive inputs to governance from all stakeholders.

Appendix A: Multilateral Instruments and Processes for Conservation and Sustainability

A.1. Introduction

This appendix provides an overview of the multilateral instruments and processes related to the conservation and sustainable use of biological resources and, in particular, genetic resources. It is not a detailed account of each and every obligation arising from these instruments but is intended to provide a general understanding of the international policy and legal scenarios in which conservation and sustainable use of genetic resources are under consideration.

Strictly, all policies and legal measures oriented towards the conservation and sustainable use of biological resources also indirectly promote the conservation and sustainable use of genetic resources contained therein. This feature could therefore open the possibility of considering an extensive set of international instruments, such as conventions addressing species and ecosystem conservation, and processes with a direct bearing on genetic resources conservation and sustainable use. However, only the major multilateral species and ecosystem conservation conventions and the more specific international agreements and processes addressing genetic resources conservation and sustainable use are considered. We address the general obligations of states that arise from international treaties and soft-law instruments [1] (notes [1–15] follow this appendix).

The analysis specifically focuses on genetic conservation and some of the legal, policy and practical implications arising from the instruments.

A.2. Agenda 21

This instrument was adopted during the UNCED meeting in Rio de Janeiro, Brazil, 1992. Although not a legally binding international instrument, Agenda 21 is an important landmark in international law as it sets a framework of principles and guidelines for sustainable development. It offers a wide range of options and alternatives for countries to promote sustainable development.

Its 40 chapters address issues that range from pollution prevention to strengthening the role of businesses and industry, from managing fragile ecosystems to strengthening the role of farmers, from children and youth and their role in sustainable development to the protection of the atmosphere. It is the most comprehensive development tool for the year 2000 and beyond. Agenda 21's implementation will be monitored and assessed periodically by the UN Commission on Sustainable Development.

Chapter 15 of Agenda 21, on the conservation of biological diversity, specifically addresses measures countries could consider or implement in order to ensure that biological diversity at the ecosystem, species and genetic level is conserved and sustainably utilised. The objectives of this chapter are '...intended to improve the conservation of biological diversity and the sustainable use of biological resources, as well as to support the Convention on Biological Diversity'.

Towards this objective, Agenda 21 proposes a series of measures and activities, including

- *conducting national assessments on the state of biodiversity (15.4(f)),*
- *developing national strategies for biodiversity conservation and making these part of overall national development strategies (15.4(b),(c)),*
- *encouraging development of traditional agricultural and agroforestry methods (15.5(d)),*
- *protecting natural habitats (15.5(g)),*
- *developing measures and arrangements towards recognising the rights of countries of origin or providers of genetic resources (15.4(j)),*
- *implementing policies for the fair and equitable sharing of benefits arising from the use of genetic resources among providers and users of these resources (15.5(e)), and*
- *developing sustainable uses for biotechnology (15.4(h)).*

A.3. The Convention on Biological Diversity

The CBD, in force since 29th December 1993, is the most comprehensive, and arguably the most important, international treaty for the conservation and sustainable use of biodiversity and its components. Although still a fairly 'young' convention and subject to difficult and often convoluted negotiations regarding its implementation, the CBD has become the main driving force of international, regional and national policy and legal efforts to conserve and sustainably use biodiversity.

The Conference of the Parties (COP) is the main governing and decision-making body of the CBD. It agrees and adopts rules of procedure for itself or any subsidiary body it may establish (for example, a working group on a particular issue), decides upon financial rules for the funding of the CBD Secretariat, reviews implementation of the CBD by considering and adopting protocols, and reviews scientific, technical and technological advice provided by the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) (Art. 23). COP decisions are the instruments which provide parties with direction on the ways in which the CBD's provisions might be implemented at national level.

The SBSTTA provides the COP and other subsidiary bodies with scientific, technical and technological advice relating to the implementation of the CBD (Art. 25). Under guidance of the COP, the SBSTTA may, *inter alia*, provide scientific and technical assessments on the conservation status of biological diversity, identify innovative, efficient and state-of-the-art technologies and know-how relating to the conservation and sustainable use of biological diversity, advise on the ways and means of promoting development and/or transfer of such technologies and provide advice on scientific programmes and international co-operation in R&D related to the conservation of biological diversity and sustainable use of its components.

A.3.1. Main Obligations Regarding Conservation and Sustainable Use of Genetic Resources

Article 1 of the CBD sets out the main objectives of this international instrument: '...the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources'. Parties to the CBD are therefore required to implement measures to ensure (*a*) that biodiversity is conserved (in *in situ* and *ex situ* conditions), (*b*) that biodiversity components (ecosystems, species and genetic resources) are used sustainably and (*c*) that the benefits arising from the use of genetic resources (e.g., in the biotechnology sector) are fairly and equitably shared among parties providing and using them.

Most CBD articles—if not all—and issues are closely interrelated. Access to and use of genetic resources (Art. 15) is closely related to technology transfer, including biotechnology (Art. 16); biotechnology is in turn related to the use of indigenous peoples' knowledge, innovations and practices (Art. 8(j)), biosafety (Arts. 8(g) and 19(3)) and intellectual property rights (Art. 16(2)). However, the CBD does not necessarily define the extent and implications of these interrelations.

The CBD is in fact a general framework and programmatic instrument that requires action at the national level to ensure its objectives are realised. Its guiding principles need specific development through national policies and legislation to become truly effective. In turn, effectiveness at the national level also depends on a series of factors, including political and financial commitments by governments.

Obligations and commitments of parties towards the implementation of the CBD can be classified in three very broad categories according to the CBD's main objectives [2].

A.3.1.1. Conservation of Biodiversity

Conservation of biodiversity can be achieved by parties through (*a*) developing national strategies, action plans and programmes (Art. 6), (*b*) identifying and monitoring biodiversity and its components (Art. 7), (*c*) promoting *in situ* conservation through the establishment of protected areas, promoting protection of ecosystems, promoting environmentally sound development in areas adjacent to protected areas, restoring and rehabilitating ecosystems, and managing the risks associated to the release of living modified organisms, among others (Art. 8), (*d*) promoting *ex situ* conservation as a mechanism to complement *in situ* measures (Art. 9), (*e*) adopting measures that act as incentives for conservation of biodiversity (Art. 11) and (*f*) promoting environmental impact assessment as a tool to determine, avoid or minimise adverse effects of projects on biodiversity (Art. 14).

A.3.1.2. Sustainable Use of Biodiversity Components

The sustainable use of biodiversity components, including genetic resources, will require parties to (*a*) develop national strategies, action plans and programmes (Art. 6), (*b*) integrate conservation and sustainable use considerations into national decision-making processes, promote traditional and local uses of biodiversity and encourage co-operation among national governments and the private sector (Art. 10) and (*c*) promote environmental impact assessment as a tool to determine, avoid or minimise adverse effects of projects on biodiversity.

A.3.1.3. Sharing of Benefits Derived from the Use of Genetic Resources

The third general objective of the CBD could be achieved by parties through (*a*) regulating access to genetic resources (Art. 15), (*b*) promoting the transfer of technologies which make use of these resources (Arts. 16 and 19) and (*c*) ensuring the availability of adequate funding, particularly for developing countries (Arts. 20 and 21).

The sustainable use of biodiversity components and sharing of benefits derived from the use of genetic resources provisions illustrate a delicate balance reached during the negotiations of the CBD's text. This balance responds to the interests of biodiversity-rich countries of the South and those of industrialised countries of the North [3] which have a direct interest in having access to potentially valuable biodiversity in the South, particularly, although certainly not exclusively, by the pharmaceutical, agro-industrial and biotechnological sectors, whose activities are based to an important extent on research of potentially valuable and useful genetic diversity.

In this context, where potentially valuable genes are yet to be discovered, the issue of controlling access to and use of genetic resources in particular has become a central issue of the CBD process. As a direct result of the CBD, and specifically its provisions on access and benefit sharing, an international negotiation process is underway [4] and national efforts are taking place, geared towards finding mechanisms through which access can be legally controlled and the benefits derived from access to and use of genetic resources can be equitably shared.

In turn, this has also triggered debates and discussion on closely related issues (also covered by the CBD), specifically on the transfer of technologies which make use of genetic resources (mainly biotechnology), intellectual property rights (which protect resulting inventions), indigenous peoples knowledge, innovations and practices related to uses of biological and genetic resources, and biosafety [5]. Arguably, Article 15 of the CBD remains the most controversial, particularly because of its complex interrelation with these issues and the potential, and yet to be fully understood, synergies between these issues [6].

According to Article 15, in their role as providers of genetic resources, contracting parties are able to regulate access to genetic resources in their territories (Art. 15(1)) on the basis of mutually agreed terms (Art. 15(4)) and prior informed consent (unless otherwise determined by the party (Art. 15(5)). But parties should also seek to facilitate access for environmentally sound uses and not impose restrictions which are contrary to the objectives of the CBD. Furthermore, their role as providers of genetic resources refers to genetic resources of which they are countries of origin or that they have acquired in accordance with the CBD principles (Art. 15(3)) [7].

In their role as users of genetic resources, contracting parties could develop and carry out scientific research with the participation of contracting parties which provide these resources and if possible in their territories (Art. 15(6)). Co-operation and joint partnerships are important elements to consider in the context of this provision. Contracting parties could also take legislative, policy and administrative measures with the aim of sharing in a fair and equitable way the results of research and development and any benefits arising from commercial and other utilisation of the providing contracting party (Art. 15(7)) [8].

Although it is states which remain the subjects of international public law (except in humanitarian international law), the CBD principles and obligations, particularly those related to access to and use of genetic resources, will be directly applicable mainly to institutions and individuals (including universities, research institutions, private companies and *ex situ* conservation institutions) who carry out activities in the fields of taxonomy, biochemistry, biotechnology, molecular biology and drug development, among others.

In this regard, companies such as Novo Nordisk, Shaman Pharmaceuticals and Glaxo Wellcome, institutions such as The Royal Botanic Gardens, Kew, UK and research programmes such as those of the US National Cancer Institute [9] (through its International Co-operative Biodiversity Group Programme), whose work involves direct use of biological and genetic resources, have implemented institutional policies regarding access to genetic resources and benefit sharing.

These policies by user institutions could become an option and incentive to promote adequate co-operation with developing country institutions. They might also have the effect of promoting the development of access regulations supportive of partnership building and co-operation rather than focused on restrictive regulatory measures or unnecessarily burdensome administrative procedures.

Benefit sharing is a central feature of the CBD. What are benefits and how can benefit sharing be achieved? The third general objective of the CBD cannot be understood in the context of any single, all-embracing interpretation. Benefits have different meanings in different circumstances. An integral interpretation of the CBD could lead to understand benefit sharing as '...the equitable exchange of access to genetic resources associated knowledge for finance, technology and participation in research' (UN 1996), where biodiversity-rich countries provide the biodiversity components and knowledge, and industrialised countries ensure financial resources for conservation and sustainable use, transfer appropriate technologies, including biotechnology, and incorporate developing country nationals into R&D processes.

Benefit sharing needs to be encouraged and in that sense, legislation, intellectual property rights, material transfer agreements, policies strategies and capacity building itself, stand as potentially useful tools with which the benefits derived from the use of genetic resources could be realised. Benefits to be shared generally include monetary benefits and nonmonetary benefits such as in-kind benefits, information, technology, training, joint R&D, institutional capacity building and local income generation and employment.

How and among whom benefits are shared will almost invariably depend on the level of involvement of the state. States may leave access and benefit sharing unregulated and leave private entities (companies, universities, individuals, indigenous peoples) to decide the conditions under which partnerships develop. States may also regulate access and benefit sharing and create the legal framework of rules and conditions which need to be complied with to access genetic resources and share benefits and even determine the level of involvement of private parties in this regulatory framework. As a third option, the state might only oversee the access and benefit sharing procedure and agreements, leaving parties to negotiate the terms and conditions.

A.3.2. The Biosafety Protocol

Another controversial issue addressed by the CBD has been the development and release into the environment of GMOs. Little is known about the potential threat of GMOs—the result of biotechnological (and particularly genetic engineering) applications—to the environment and on human and animal health, although many scientists are calling for a precautionary approach to the development and use of these organisms. The CBD has explicitly acknowledged this concern and the importance of this particular issue.

In this regard, Article 8(g) calls upon parties, as far as possible and appropriate, to '…establish or maintain means to regulate, manage or control the risks associated with the use and release of living modified organisms resulting from biotechnology which are likely to have adverse environmental impacts that could affect the conservation and sustainable use of biological diversity, taking also into account the risks to human health'.

Furthermore, Article 19(3) of the CBD also recognises the need for parties to consider '...the need for and modalities of a protocol setting out appropriate procedures, in particular, advanced informed agreement, in the field of the safe transfer, handling and use of any living modified organism resulting from biotechnology that may have adverse effect on the conservation and sustainable use of biological diversity'.

Finally, Article 19(4) determines that '…each Contracting Party shall, directly or by requiring any natural or legal person under its jurisdiction providing the organism referred to...provide any available information about the use and safety regulations required by that Contracting Party in handling such organisms, as well as any available information on the potential adverse impact of the specific organism concerned to the Contracting Party into which those organisms are to be introduced'.

According to the guidance provided to the COP, the development of a protocol should prioritise (*a*) the elaboration of the key concepts and terms that are to be addressed in the (negotiation) process, (*b*) the inclusion of considerations on the form and scope of advance informed agreement procedures and (*c*) the identification of relevant categories of GMOs resulting from biotechnology. Additionally, the protocol should reflect that '...its effective functioning requires that parties establish or maintain national measures, but the absence of such measures should not prejudice the development, implementation and scope of the protocol'.

Most importantly, the protocol should take into account the Rio principles, in particular the precautionary approach included in Principle 15, and (*a*) not exceed the scope of the CBD, (*b*) not duplicate or override any other international instrument in this area, (*c*) provide for a review mechanism and (*d*) be efficient and effective and minimise unnecessary negative impacts on biotechnological R&D and not unduly hinder access to, and transfer of, technology.

A working group has met on numerous occasions. Substantial progress in 1999 led to a Draft Protocol on Biosafety being discussed by the COP in Montreal in January 2000. The Cartagena Protocol on Biosafety was agreed to by almost 70 countries during the COP-5 meeting in Nairobi in May 2000. This provides a mechanism for assessing risks and benefits in a manner which inspires public and political confidence.

A.4. CITES

Trade in endangered species and the demand for scarce and exotic wildlife (e.g., rare cacti and orchids) and their products (e.g., elephant ivory and tiger bones) have become critical driving forces behind the problem of species extinction and biodiversity loss in general. Trade is recognised as having devastating effects on ecosystems and species diversity. The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) regulates international trade in threatened and endangered species. It is basically a border control mechanism to restrict and monitor the flow of rare species and parts of species across national boundaries. The level of restriction placed on the trade of specific species depends on the listing status of these, varying from very strict to more lenient. It should be noted that CITES does not regulate the protection of species within national borders but rather applies to the international movement and commercialisation of these species. Protection at the national level of habitats and species remains within the regulatory powers of individual states.

The CITES protection mechanism is based on recommendations (Appendices I, II and III) which establish different levels of permit requirements for the export and import of listed species and parts thereof. The listing determines the level of protection or restrictions placed on trade. Species listed in Appendix I are the most protected. Species in Appendix II include species which may become threatened with extinction unless trade is strictly controlled and monitored. Finally, species listed in Appendix III are those which a party protects domestically (through national laws) but for which further co-operation is required from CITES parties to control their international trade. Listing of species is carried out on the basis of voting at the COP. A two-thirds majority is required to amend (add or eliminate species) listings in Appendix I and II, whereas for Appendix III a party may amend the listing whenever it chooses.

Does CITES relate to the conservation, and specifically access to and use, of genetic resources? Having been in force for over 20 years, CITES does offer examples of specific procedures for enabling the control of export and import of specimens of biological resources (and therefore genetic resources) and could provide the CBD process with valuable experiences in the area of functions of management authorities in exporting and importing countries, in the review process of export permits by importing countries and in the operation of administrative procedures in exporting and importing countries in general. Unlike regulatory mechanisms being designed by countries to regulate access to their genetic resources, CITES offers an interesting example of a regulatory system where the exporting and importing countries, through a permit system and elaborate administrative procedures, seek to ensure sustainability in the trade of species and derived products. CITES could provide support for the substantive as well as procedural aspects of implementing the CBD's Article 15.

A.5. The Ramsar Convention

Conservation of specific ecosystems—wetlands in the case of the Ramsar Convention—is an indirect mechanism for *in situ* conservation of genetic diversity. The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (signed in Ramsar, Iran in 1971 and entered into force on December 21st, 1975) binds contracting parties with obligations covering site- and non-site-specific measures as well as promoting international co-operation for the conservation and management of wetlands on the basis of nationally selected and listed wetlands.

The Ramsar Convention seeks to protect wetland ecosystems, which vary broadly and include coastal beaches, mangrove swamps, mountain lakes and tidal flats. Article 1(1) defines wetlands as '...areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres'. It also intends to protect waterfowl, defined in Article 1(2) as '...birds ecologically dependent on wetlands'. Through the protection of ecosystems and certain species, genetic diversity within these ecosystems or dependent on them is maintained. The preamble of the convention recognises that conservation of wetlands and their flora and fauna, and by implication their genetic diversity at species and microbial level, can be ensured by a combination of national policies and international co-operation, including technical and financial assistance.

Each contracting party is required to list at least one wetland in the List of Wetlands of International Importance (Art. 2(1)), based upon criteria including the international significance of the ecology, botany, zoology, limnology, hydrology and importance to waterfowl (Art. 2(2)). Parties should also promote the conservation of wetlands whether they are specifically listed or not (Art. 4(1)).

In order to promote the conservation of wetlands, contracting parties should formulate and implement planning for those wetlands listed and, as far as possible, promote the wise use of wetlands within their jurisdiction (Art. 3(1)). The nature of the planning is not specified, but parties should adopt measures to safeguard the ecosystems against damaging processes and activities according to their own legal systems and social and economic circumstances (Davis, 1993).

A.6. The UN Convention to Combat Desertification

Desertification is a serious environmental and social problem affecting and threatening the livelihoods of over one billion people in more than 100 countries, particularly on the African continent. Desertification is mostly associated with deserts and their expansion to productive lands, but desertification can occur in virtually any arid area where climatic or human-induced processes (including overgrazing, overcultivation and deforestation) debilitate the land's ability to support plant and animal growth. Soil degradation and the loss of biodiversity are the most obvious expressions of a desertification process.

The main objectives of the Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (CCD, adopted in 1994 and in force since December 26th, 1996) are '...to combat desertification and mitigate the effects of drought...through effective action at all levels, supported by international co-operation and partnership agreements...' (Art. 2(1)) and through '... long-term integrated strategies that focus simultaneously, in all affected areas, on improved productivity of land, the rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions particularly at the community level' (Art. 2(2)). Unlike most international agreements, the CCD requires states to channel authority and resources to local land users and communities, including NGOs. It seeks to encourage new partnerships which link states, international institutions, NGOs and local communities.

National Action Progammes (NAPs) to combat desertification (Art. 9) are at the core of the CCD and should be developed in the context of fully participatory processes (Art. 10). NAPs should be developed taking into consideration long-term goals for affected areas, specifying the measures to be taken to improve economic and social conditions in affected areas. These measures could include mechanisms to ensure conservation of biodiversity in these areas, the design of contingency plans and effective early warning systems. Article 19 of the CCD is particularly important in that it calls for the full participation of local people in training and institutional programmes directed to combat desertification and mitigate the effects of drought and participate in the actual design and implementation of these programmes.

The CCD's main relation with biodiversity is related to the fact that through the process of desertification, ecosystems, species and genetic diversity are being lost. Biotechnology might play a key role in combating desertification. Plants and animals in drylands typically exhibit unusual genetic traits, usually related to resistance to extremely dry ecosystems. But genetic diversity in these areas is at the same time limited and thus susceptible and vulnerable to loss and extinction. In this regard, assessing and mapping biodiversity in dryland regions and its subsequent conservation become of critical importance and relevance.

A.7. The FAO IU on Plant Genetic Resources

The IU was the first comprehensive international instrument to address the conservation and use of genetic resources, specifically in the area of plant genetic resources. The undertaking was adopted by Resolution 8 of the 1983 FAO Conference. Although a nonbinding international instrument, its provisions affect international and national policies related to the conservation and use of plant genetic resources. The main objectives of the IU are to '...ensure that plant genetic resources of economic and/or social interest, particularly for agriculture, will be explored, preserved, evaluated and made available for plant breeding and scientific purposes' (Art. 1). The undertaking is based '...on the universally accepted principle that plant genetic resources are a heritage of mankind and consequently should be available with no restrictions' (Art. 1).

Since then, as a result of reservations about the IU, there has been a series of interpretations and complementary resolutions negotiated through the Commission on Genetic Resources for Food and Agriculture, which have now become annexes to it [10]. They include

- Resolution 4/89 (Annex I) provided an agreed interpretation of the undertaking which recognised that plant breeders rights, as provided by the UPOV, were not inconsistent with the convention.
- Resolution 5/89 (Annex II) recognised the concept of 'farmers' rights' as 'rights arising from the past, present and future contributions of farmers in conserving, improving and making available plant genetic resources, particularly those in centres of origin/diversity'. These rights are vested in the international community, as trustee for present and future generations of farmers, for the purpose of ensuring benefits to farmers and supporting the continuation of their contributions, as well as the attainment of the overall purposes of the IU.
- Resolution 3/91 (Annex III) reaffirmed that the concept of human heritage is subject to the sovereign rights of states over their plant genetic resources, and furthermore agreed that farmers' rights would be implemented through an International Fund on Plant Genetic Resources to support conservation and utilisation programmes.

The 27th Session of the FAO Conference in 1993, in response to the requests made in Agenda 21 and Resolution 3 of the Final Act of the Nairobi Conference (which adopted the CBD and recognised the need to seek solutions to outstanding matters concerning plant genetic resources, including access to *ex situ* collections not acquired in accordance with the CBD and the issue of farmers' rights) adopted Resolution 7/93 which called for (*a*) the adaptation of the IU in harmony with the CBD, (*b*) the consideration of access on mutually agreed terms to plant genetic resources, *inter alia*, including *ex situ* collections not addressed by the CBD and (*c*) the issue of realising farmers' rights.

During the Fourth International Technical Conference of FAO held in Leipzig in 1996, countries emphasised the importance of completing the revision of the Undertaking and furthermore the adjustment of the Global System for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (see Section A.9).

Although the CBD and the IU converge in a number of aspects, such as the possibility under both agreements to provide for access to genetic resources on the basis of mutually agreed terms and through a multilateral or bilateral mechanism, they do present some major differences: the CBD's scope is much broader as it encompasses all genetic resources; the IU is more geared towards seeking multilateral solutions to access and benefit sharing in the field of plant genetic resources for food and agriculture. Additionally, whilst the CBD is a legally binding agreement, the IU is not [11]. Negotiations are still underway to harmonise the CBD and the IU.

A.8. The FAO International Code of Conduct

The International Code of Conduct for Plant Germplasm Collecting and Transfer was adopted by the FAO Conference in 1993 as Resolution 8/93. It is a voluntary, nonbinding instrument that provides guidelines which governments may use when developing national policies and drafting national regulations regarding access to plant germplasm. Countries participating in the Fourth International Technical Conference recognised that the code was proving useful in the development of national regulations on access to and transfer of plant germplasm (genetic resources in general).

The code's main objectives include the promotion of conservation and collection and utilisation of plant genetic resources in a way which respects the environment and local traditions and cultures; it also seeks to promote participation of national researchers in conservation and sustainable use programmes as well as the promotion of equitable sharing of benefits derived from the use of the collected resources, particularly with farmers and local communities (Art. 1).

Article 3 recognises the voluntary nature of the code and the sovereign rights of states over their plant genetic resources. It acknowledges that it is mainly directed to governments, offering a set of principles they might want to consider when developing national policies and regulations, but it also seeks to encourage natural and legal persons (including seed banks, botanical gardens and the agro-industrial and pharmaceutical sectors) to abide by its provisions.

Article 4.1 establishes the scope of the code. It refers to the shared responsibilities of collectors, donors, sponsors and users of germplasm in order to ensure that collection, transfer and use of plant genetic resources generate the maximum benefit for the international community and minimises adverse effects on cultivated species and the environment. It further states that although initial responsibility is placed on the field collectors and their sponsors, these should extend to those parties which support or authorise the collection or donate, conserve and utilise the germplasm. The code emphasises the need for co-operation among all those involved and reciprocity between donors, sponsors and users. Governments should additionally consider the possibility of applying the code's principles.

Article 15 finally addresses the obligation of governments of informing the Commission on Genetic Resources for Food and Agriculture on the measures adopted at the national level to implement the code.

The importance and usefulness of the code stems from the fact that it is clearly directed at the collection and transfer of plant germplasm. Most regulations covering access to genetic resources currently in place apply uniformly to all forms and sources of genetic resources and uses of these (plants, animals, micro-organisms; forests, *ex situ* centres, marine sources; basic research, agricultural research and pharmaceutical use, respectively). Most analysts recognise the need to distinguish between different resources, their different sources and their different purposes and therefore design regulatory regimes accordingly.

A.9. The FAO Global Plan of Action

The FAO Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture is a component of the Global System for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (which in turn derives from Article 7.1 of the IU) which calls for the development of a global system to ensure (*a*) the development of a network of *ex situ* national centres, (*b*) an increase in the number of these centres, (*c*) the development of scientific criteria for collecting, conservation, evaluation and exchange of plant genetic resources, (*d*) financial support, (*e*) the development of an information global network under FAO coordination, (*f*) the development of a warning system, (*g*) that CGIAR carries out its activities in coordination with FAO and (*h*) that institutional and human capacities of developing countries are enhanced.

In this sense, the Global System [12] was fundamentally developed in order to ensure the safe conservation, and promote the availability and sustainable use, of plant genetic resources for food and agriculture for present and future generations. The Global System is based on the principles that (*a*) nations have sovereign rights over plant genetic resources in their territories, (*b*) plant genetic resources should be available for the benefit of humanity, on mutually agreed terms, for plant breeding and scientific purposes, (*c*) plant genetic resources, information, technologies and funds to conserve and use them are complementary, (*d*) all nations are potential donors and users of plant genetic resources, (*e*) farmers of the world have over centuries, domesticated, conserved, developed, improved and made available plant genetic resources, (*f*) advanced and rural technologies are both important and complementary and (*g*) *in situ* and *ex situ* conservation are complementary strategies for maintaining genetic diversity (FAO, 1996).

The Global Plan of Action, adopted during the Fourth Technical Conference on Plant Genetic Resources in Leipzig, in 1996, is basically a set of recommendations and activities derived from the findings of the Report on the State of the World's Plant Genetic Resources [13]. The Global Plan of Action is a framework and guidance set of recommendations intended to trigger action at the local, national and international levels. It seeks to create an efficient system for the conservation and sustainable use of plant genetic resources through better co-operation, coordination and planning and institutional capacity building [14].

The overall objectives of the Global Plan of Action are to ensure the conservation of plant genetic resources for food and agriculture as the basis for food security, to promote sustainable use of plant genetic resources to foster development and reduce hunger and poverty, to promote the fair and equitable sharing of benefits arising from the use of plant genetic resources, to assist countries and institutions to identify priorities for action, and to strengthen existing programmes and enhance institutional capacities. The implementation of the Global Plan of Action will be guided and monitored by the FAO Commission on Genetic Resources for Food and Agriculture.

The Report of the State of the World's Plant Genetic Resources made it clear that four major areas of concern need to be urgently addressed:

(1) *In situ* conservation and development. To improve the management of plant genetic resources in *in situ* conditions, the Global Plan of Action recommends

- surveying and monitoring,
- supporting on-farm management and improvement,
- assisting farmers in restoring agricultural systems, and
- promoting *in situ* conservation of wild crop relatives and wild plants for food production.

(2) *Ex situ* conservation. To improve *ex situ* conservation of plant genetic resources, the Global Plan of Action recommends

- sustaining existing *ex situ* collections,
- regenerating threatened *ex situ* accessions,
- supporting planned and targeted collecting, and
- expanding *ex situ* conservation activities.

(3) Use of plant genetic resources. In order to improve the use of plant genetic resources, the Global Plan of Action recommends

- expanding characterisation and evaluation and number of core collections to facilitate use,
- increasing genetic enhancement and base-broadening efforts,
- promoting sustainable agriculture,
- promoting the development and commercialisation of under-utilised crops and species,
- supporting seed production and distribution, and
- developing new markets for local varieties and diversity-rich products.

(4) Institution and capacity building. To strengthen institutions and promote capacity building, the Global Plan of Action recommends

- building strong national programmes,
- promoting networks,
- constructing comprehensive information systems,
- developing monitoring and early warning systems,
- expanding education and training, and
- promoting public awareness.

Following the adoption of the Global Plan of Action, countries, institutions and organisations concerned with the conservation and sustainable use of plant genetic resources have started to use their own resources and existing capacities towards its effective implementation. However, the plan's full and effective implementation requires a substantial increase in the levels of activities and funding. The International Technical Conference in Leipzig recognised the need for financial resources to ensure effective implementation of the Global Plan of Action.

A.10. TRIPS

TRIPS is a trade-related agreement of the GATT signed in Marrakesh, Morocco, on April 15th, 1994 and currently administered by the WTO. TRIPS addresses intellectual property protection in the area of copyrights, trademarks, geographical indications, industrial designs, patents (and plant variety protection), layout designs of integrated circuits, protection of undisclosed information and anticompetitive practices controls. Of these different instruments, the protection of patents and plant variety (through plant breeders rights) are the most relevant regarding implementation of the CBD, and the conservation and sustainable use of biodiversity and its components in particular.

According to Article 27, '…patents shall be available for any inventions, whether products of processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application'. Paragraph 1 of Article 27 also requires that patents be available and rights enjoyable '...without discrimination as to the place of invention, the field of technology and whether products are imported or locally produced'. Particularly in the USA, Europe and most industrialised countries, the granting of patents over life forms (genes, seeds, animals, plants, micro-organisms, among others) is becoming a common trend as biotechnology, agro-industrial and pharmaceutical companies seek protection for their investments in R&D processes. Biodiversity components are currently an important asset for these industries, and therefore the need for them to seek protection for the products (inventions) derived from these components.

The CBD has specifically addressed the potentially complex interrelation between biodiversity and intellectual property. Article 16(5) points out that '…Contracting Parties, recognising that patents and other intellectual property rights (mainly plant breeder rights) may have an influence on the implementation of the Convention, shall co-operate in this regard, subject to national legislation and international law in order to ensure that such rights are supportive of and do not run counter to its objectives'.

In this sense, the CBD acknowledges that intellectual property rights could have impacts regarding the conservation and sustainable use of biodiversity and its components. Moreover, Decision III/17 of COP 3 also recognised that '...further work is required to help develop a common appreciation of the relationships between intellectual property rights and the relevant provisions of the Trade Related Aspects of Intellectual Property Rights and the Convention on Biological Diversity in particular on issues relating to technology transfer and the conservation and sustainable use of biological diversity and the fair and equitable sharing of benefits arising out of the use of genetic resources, including the protection of knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity'.

Some analysts suggest that intensive agricultural practices, supported by the use of protected technologies and products, are an important cause of genetic erosion and loss of agro-biodiversity in traditional agricultural systems. Displaced native and local land races, heavy dependence of farmers on agrochemical inputs (suited for specific types of seeds) and therefore soil and ecosystem degradation are some of the arguments most commonly used to challenge the use of intellectual property over life forms. More recently, biotechnology and GMOs and products—mostly protected by patents or plant breeders rights—are additional elements considered potentially dangerous, particularly in the context of agricultural development. Last but not least, some argue that intellectual property rights are an outright theft of resources and knowledge generated over centuries by indigenous and local communities which have traditionally conserved, nurtured and enhanced biological diversity and its components.

Although, unlike previous intellectual property agreements, TRIPS provides mandatory minimum protection standards on what is protectable subject matter that must be adopted by countries, it does allow for certain exclusions with respect to what can be patentable or not, and therefore allows a level of discretion for countries. Article 27(2) enables members to exclude from patentability '...inventions, the prevention within their territory of the commercial exploitation of which is necessary to protect the *ordre publique* or morality, including to protect human, animal or plant life or health or to avoid serious prejudice to the environment, provided that such exclusion is not merely because the exploitation is prohibited by their law'. Experts tend to agree that there are no unequivocal interpretations on what *ordre publique* or morality actually mean in the context of TRIPS. There is a general feeling that governments will have the possibility to use this exception on a case-by-case basis but not apply it to broad classes of patents, defined for example by the notion of 'life forms' (Moufang, 1998).

Article 27(3b) establishes that member states may exclude from patentability '...plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than nonbiological and microbiological processes. However, Members shall provide for the protection of plant varieties either by patents or by an effective *sui generis* system or by any combination thereof. The review of this sub-paragraph shall be reviewed four years after the entry into force of the WTO Agreement'.

The exact meaning of this provision is subject to continued debate. What are the substantial differences between a 'plant' and a 'plant variety'? The former cannot be patented, but for the latter, protection must be provided by patents, a *sui generis* system or a combination of both. The *sui generis* option for protection is usually related to the protection provided by UPOV, which enables new, stable, homogeneous, and distinct plant varieties to be protected under an international regime for plant breeders' rights. Some argue that the *sui generis* option would enable countries to develop their own protection system according to national needs and agro-ecological and technological features.

Patents must also be available for micro-organisms as products and for nonbiological and microbiological processes for producing plants and animals. This provision is clearly targeted at enabling biotechnological products and processes to be susceptible of patent protection.

The main feature of Article 27(3b) and the patent system as developed by TRIPS is the possibility that genetic resources can be subject to protection and therefore to restrictions in their utilisation. It is far from clear what the consequences of these restrictions might be but, certainly in the biotechnological area, R&D could be hampered if availability of the protected material is unnecessarily restricted [15].

A.11. Indigenous Peoples' Knowledge and WIPO

The relation between indigenous peoples' knowledge and biodiversity and its importance has long been recognised, particularly by anthropologists, sociologists, biologists and ecologists, as a critical component of any biodiversity conservation and sustainable use effort. International law, however, has given recognition to this relation only recently, although in numerous binding and nonbinding instruments. Agenda 21 (1992), the 1983 IU (through the farmers' rights concept), the CBD (1992), the ILO Convention on Indigenous and Tribal People in Independent Countries (1991), the Mataatua Declaration on Cultural and Intellectual Property Rights of Indigenous Peoples (1993), the Kari-Oca Declaration and the Indigenous Peoples' Earth Charter (1992) and, most recently, regulations relating to access to and use of genetic resources (e.g., Decision 391 of the Andean Community, Executive Order 247 of the Philippines, Law 7788 of Costa Rica), all have in common a specific reference to indigenous peoples' intellectual effort (knowledge, innovations and practices) associated to biodiversity conservation and use.

With the TRIPS discussions and the granting of patents over biodiversity elements which indigenous peoples might have knowledge related to, indigenous peoples' knowledge, innovations and practices have become firmly established as a distinct issue on the international environmental and development agenda. Furthermore, efforts are being undertaken at the national, regional and international level to develop effective mechanisms to (*a*) protect indigenous peoples' knowledge, innovations and practices from illegal use and (*b*) ensure that benefits are shared for the use of indigenous peoples' knowledge, innovations and practices.

These policies, regulations and project-oriented measures being developed and efforts undertaken vary considerably according to specific circumstances. Mechanisms being assessed include

- *Legal instruments:* contracts, traditional intellectual property instruments such as patents, certifications of origin, trade secrets, plant breeders rights, access to genetic resources regulations, *sui generis* options;
- *Funds:* FAO International Fund on Plant Genetic Resources, Andean Fund on Genetic Resources, Genetic Resources Recognition Fund (University of California), Fund for the Integrated Rural Development and Traditional Medicine (Nigeria), Forest Peoples' Fund (Suriname);
- *Project-oriented measures:* GEF Peruvian project for *In Situ* Conservation of Native Land Races, Peoples' Biodiversity Registers (India).

These efforts are mostly nationally driven. Although the development of an international, legally binding system for the protection of indigenous knowledge is a long-term and politically complicated goal, certain intergovernmental institutions are taking increased interest in exploring how the expressions of indigenous intellectual efforts may be protected from illegal or unauthorised uses or other abuses.

WIPO, through its Main Programme 11 on Global Intellectual Property Issues, formally began to address some of the issues related to indigenous peoples' intellectual property in late-1997, the main objectives being to

- identify and explore emerging global issues at the frontier of intellectual property system in the context of their social, cultural, and economic impact at the national, regional and international level,
- promote understanding of the relation between intellectual property and multilateral instruments on global issues,
- identify and explore new approaches to the use of the intellectual property system by new beneficiaries as holders of indigenous knowledge and innovations,
- examine the role of intellectual property in the preservation, conservation and dissemination of biological diversity,
- investigate the need for, and possible nature and scope of, new adapted forms of protection for folklore expressions, including a new international treaty, and
- examine policy options for the use and management of intellectual property in relation to evolving notions of territoriality.

The programme is divided into four sub-programmes: 11.1, Intellectual Property Rights for New Beneficiaries; 11.2, Biological Diversity and Biotechnology; 11.3, Protection of Expressions of Folklore and 11.4, Intellectual Property Rights Beyond Territoriality. Although linkages to biodiversity can be identified in all four of these sub-programmes, particularly relevant are sub-programmes 11.1 and 11.2.

Sub-programme 11.1 on Intellectual Property Rights for New Beneficiaries seeks to promote understanding in other international fora of the universal aspects of intellectual property rights, identify and explore the intellectual property needs and expectations of new beneficiaries, including the holders of indigenous knowledge and innovations, in order to promote the contribution of the intellectual property system to their social, cultural and economic development, and institute pilot projects for new approaches to the creation, protection, use and management of intellectual property rights for new beneficiaries.

Sub-programme 11.2 on Biological Diversity and Biotechnology seeks to examine the role of intellectual property in the preservation, conservation and dissemination of global biological diversity, and examine the potential of new technologies in the management of intellectual property for the documentation, conservation and dissemination of global biological diversity.

NOTES

[1] Soft law refers to legal instruments such as declarations of principles, resolutions of international organisations or charters which are nonbinding by nature. These legal instruments offer principles and guidelines which countries may or may not take into consideration when defining their internal policies and developing regulations. They do not contain legal obligations that can be enforced.

[2] This classification is not a comprehensive or exhaustive list of the specific obligations of the CBD. This list merely illustrates some of the areas in which national governments may need to act in order to conserve, sustainably use and share benefits from biodiversity according to national priorities.

[3] The biodiversity-rich versus biodiversity-poor and North–South paradigm is not an absolute nor necessarily precise distinction (e.g., USA is a biodiversity-rich country). However, it is helpful for understanding context and interests at play during the CBD negotiation process.

[4] This international negotiation process includes the CBD and FAO fora. Essentially, the guiding principles include drawing upon 'all relevant sources, including legislative, policy and administrative measures, best practices and case studies on access to genetic resources and benefit sharing arising from the use of those genetic resources, including the whole range of biotechnology, in the development of a common understanding of basic concepts and all options for access and benefit sharing on mutually agreed terms including guiding principles, guidelines and codes of best practice for access and benefit sharing arrangements'.

[5] Traditional Knowledge and Biological Diversity and Biosafety Protocol: two evolving topics closely related to genetic resources conservation and sustainable use.

[6] Article 15:

(1) Recognising the sovereign rights of states over their natural resources, the authority to determine access to genetic resources rests with the national governments and is subject to national legislation.

(2) Each Contracting Party shall endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other Contracting Parties and not to impose restrictions that run counter to the objectives of the Convention.

(3) For the purpose of this Convention, the genetic resources being provided by a Contracting Party, as referred to in this Article and Articles 16 (Access to and Transfer of Technology) and 19 (Handling of Biotechnology and Distribution of its Benefits) are only those that are provided by Contracting Parties that are countries of origin of such resources or by the Parties that have acquired the genetic resources in accordance with this Convention.

(4) Access, where granted, shall be on mutually agreed terms and subject to the provisions of this Article.

(5) Access to genetic resources shall be subject to the prior informed consent of the Contracting Party providing such resources, unless otherwise determined by that Party.

(6) Each Contracting Party shall endeavour to develop and carry out scientific research based on the genetic resources provided by other Contracting Parties with the full participation of, and where possible in, such Contracting Parties.

(7) Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, and in accordance with Articles 16 and 19 and, where necessary, through the financial mechanism established by Articles 20 and 21 with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilisation of genetic resources with the Contracting Party providing such resources. Such sharing shall be upon mutually agreed terms.

[7] Development of policies and legislation in relation to national access to genetic resources has been a defining feature of the implementation process of the CBD.

[8] Specific measures that could be adopted by user countries could include ensuring that the granting of intellectual property rights (basically patents and plant breeders' rights) is subject to verification of the legal origin of genetic resources incorporated in the product to be protected.

[9] The US has still to ratify the CBD. However, it is quite striking that a number of US institutions are in fact incorporating the CBD principles, particularly those referring to access and benefit sharing, into their institutional policies.

[10] The Commission on Genetic Resources for Food and Agriculture (originally the Commission on Plant Genetic Resources) was established by Resolution 9/83 of the 1983 FAO Conference. It is an intergovernmental forum where countries can discuss matters related to plant genetic resources for food and agriculture and monitor the implementation of the IU.

[11] Decision III/11 of the Third COP of the CBD held in Buenos Aires, Argentina in November 1996, noted '...that the various options for the legal status of a revised International Undertaking on Plant Genetic Resources, which include a voluntary agreement, binding instrument, or protocol to the Convention on Biological Diversity, have not been decided upon by the Food and Agriculture Organisation of the United Nations, requests [the COP of] the Food and Agriculture Organisation to inform the Conference of the Parties of its deliberations, affirms its willingness to consider a decision of the Conference of the Food and Agriculture Organisation of the United Nations that the International Undertaking should take the form of a protocol to this Convention once revised in harmony with this Convention and further requests the Executive Secretary to inform the Commission on Genetic Resources for Food and Agriculture accordingly'. This decision also called for an '...effective and speedy completion of the revision of the International Undertaking and strengthening of the FAO Global System'.

[12] The component parts of the Global System coordinated by the Commission on Genetic Resources for Food and Agriculture are the IU, international funds and funding mechanisms, the Global Plan of Action, the Report on the State of the World's Plant Genetic Resources for Food and Agriculture, the World Information and Early Warning System, the *Ex situ* Network of Base Collections, Crop and Thematic Networks and Codes of Conduct and Guidelines.

[13] The Global Plan of Action and the Report on the State of the World's Plant Genetic Resources were prepared through a country-driven process guided by the Commission on Genetic Resources for Food and Agriculture. 158 countries prepared country reports and 143 of them participated in 12 sub-regional and regional preparatory through which sub-regional synthesis and recommendations were made as inputs to the Global Plan of Action.

[14] Decision III/11 of COP 3 of the CBD, welcomed '...the contribution that the Global Plan of Action for the Conservation and Sustainable Uses of Plant Genetic Resources for Food and Agriculture, as adopted by the Fourth International Technical Conference on Plant Genetic Resources, provides to the implementation of the Convention on Biological Diversity in the field of plant genetic resources for food and agriculture and encourages parties to actively implement the Global Plan of Action in accordance with their national capacities, and endorses its priorities and policy recommendations'.

[15] In theory, the UPOV system, through its 'breeders' exemption' and the research exemption for noncommercial applications in the patent system, would enable further research and development to be carried out although the 'essentially derived variety' former and complex patent claims in the patent system make it difficult in many instances to make these exemptions effective.

Appendix B: *Ex situ* Genebanks

B.1. What Are Genebanks?

Genebanks are facilities designed to maintain germplasm collections. They are needed for two major reasons: to provide genetic diversity for immediate and future use by breeders, and to conserve materials for direct use by farmers and rural communities, for example through the re-introduction of local varieties that have been lost. The samples included in the collections therefore need to be readily accessible for current use and secure in the medium to long term. Originally, collections were held in so-called 'genetic resources centres' but since the storage required infrastructure, often including refrigeration, the collections came to be known as 'genebanks'.

Most genetic samples of crop plants are seed materials, because seed of most species can be stored when dried and held at reduced temperatures. However, some materials cannot be stored in this way and for other materials it is not appropriate: for example in the case of clonally propagated genotypes and sexually sterile materials. For these, tissue culture collections and collections of growing plants (orchards, woodlots, etc.) have been developed. These too became known as genebanks, although plant maintenance could only be considered long-term in the case of long-lived tree species grown in field genebanks, and tissue cultures maintained under cryopreservation.

B.1.1. Are Genebanks Necessary?

Over the past 4–5 decades there has been a major substitution worldwide of traditional crop varieties by modern high-yielding ones. The improvement of varieties through breeding has had a range of objectives varying from all-around improvement in yield, agronomic characters and disease and pest resistance to changing the morphology, enhancing nutritional quality, or remedying a specific defect (for example, susceptibility to a widespread pest or disease).

Plant breeding over the past decades has relied on the availability of germplasm from collections held in genebanks, as well as from a wide range of other sources. Traditional farmer varieties, or land races, were widely used in breeding the new modern high-yielding varieties that triggered the 'green revolution'. They are tending to become less important, however, especially in modern commercial plant breeding, although they are still widely used in the breeding programmes of the CGIAR centres dealing with the major staple crops, so important to food security.

In contrast to modern varieties that tend to be genetically uniform, land races are characterised by a high degree of genetic heterogeneity. This enabled crops to adapt to changing environments as they became widely spread from their early origins. Modern varieties, however, have been developed for increasingly sophisticated agronomic practices and markets, a different scenario to the historical one. If breeders had not started to collect diverse materials in the 1930s and 1940s and assemble them in collections, many of the major advances of the past few decades would not have occurred. This fact became a justification for maintaining, and developing new, genebanks.

B.1.2. The Changing Role of Genebanks

The role of genebanks is changing, or set to change, in response to

(1) newer methods of conservation: e.g., ultra-low drying of seeds reducing the need for large refrigeration plants; or the use of domestic deep freezers rather than large cold chambers (in fact this has been recognised for at least 20 years and implemented in some cases);
(2) changing methods of breeding: e.g., the increasing emphasis on alleles as single genetic entities rather than adapted assemblies of alleles, as a result of the new genetic engineering techniques; such a trend calls into question the types of materials that should be maintained in genebanks—should genebanks aim to conserve and make available the maximum number of alleles within a species or the maximum number of genes irrespective of species?
(3) trends away from a limited number of international genebanks focusing on individual major staple crops, or regional multicrop genebanks in centres of diversity, towards national multicrop collections; such trends reflect, at least in part, the desire of countries to exercise their sovereign rights over genetic resources as recognised by the CBD and
(4) a new focus of the international community on more sustainable agriculture, reducing off-farm inputs and recognising the role of diverse agriculture systems at the local community level.

These changes have led some to question the need for large genebanks, while the wisdom of basing conservation and agricultural development efforts largely on local *in situ* gene management programmes is questioned by others.

B.2. Short- and Long-term Problems

B.2.1. Current and Predicted Usage

The use that can be made of materials from genebanks relates directly to how the genebanks are managed. For instance, relevant data are essential if users are to make informed choices of material for breeding. In addition, there has to be an adequate number of qualified plant breeders. There are constraints in both these areas, particularly in relation to many national genebanks. First, their management has often been less than rigorous and second, many countries still lack an adequate cadre of plant breeders.

This problem is compounded by the fact that large germplasm collections can present severe management problems. This is exacerbated by the fact that aid donors have, in many instances, provided very large facilities to developing countries and such facilities can be over-costly to maintain.

Thus the potential use of materials depends on (*a*) their quality, (*b*) knowledge about them and (*c*) their management. Many of the constraints associated with these three factors can be resolved when genebanks collaborate with others with similar interests. However, such collaboration is being hampered by recent trends to restrict access.

As pointed out above, new uses are emerging for genebank collections. Although it has been widely observed that *ex situ* germplasm collections are often underused by plant breeders, this is certainly not an argument for their neglect. Ethical and moral considerations alone justify conserving the materials for the future. Rational conservation can be achieved through the use of long-term storage, reducing the size of collections in active use and implementing appropriate management strategies and national policies.

Such actions need to be coupled with sound policies at the national level in relation to plant production (including breeding of staple crops, alternative agriculture, sustainable agriculture and new crops for domestic and export markets) as well as in relation to the environment. Few countries have such integrated policies.

In part, constraints in policy and institution development, especially in developing countries, may relate to the success of the CGIAR centres in making available large numbers of progeny from their breeding programmes for local assessment and selection. In many cases, countries have, to a degree, abrogated their plant breeding responsibilities.

B.2.2. Availability of Materials

Attitudes toward genetic resources have shifted, from their being widely regarded as the ‘common heritage of humankind’ to being considered national property. Under the CBD, access is to be based on the prior informed consent of the party providing the germplasm and on reaching agreement on the terms under which access will be granted. Since the major ‘world’ collections of germplasm of the most important staple crops were amassed before the CBD, the member governments of the FAO Commission and the CGIAR centres have agreed to manage these collections for the continued benefit of all (see Section B.4).

All nations will need to sort out policies on the terms and conditions under which they will permit access to their collections. Some (for example, the Philippines) have already have done this; others have not, and are awaiting the outcome of the current renegotiation of the IU by the FAO before enacting national legislation. However, the slow pace of the negotiations is leading many countries to enact legislation anyway. The longer the delay in reaching agreement, the more countries will enact legislation—and often somewhat restrictive legislation—further increasing the difficulty of the renegotiation. Such national legislation generally reflects a somewhat rigid interpretation of the CBD and, while this may be appropriate for certain classes of genetic resources (e.g., for pharmaceuticals), it is not necessarily in the best national interest for plant genetic resources for food and agriculture. As a result of the uncertainties surrounding access policies and legislation, the national and international flow of materials appears to have decreased.

B.2.3. Global, Regional, National and Local Genebanks

Some of the problems of managing national genebanks and using the materials within them (e.g., high costs and lack of facilities and trained human resources) could be solved by developing regional collections. This has been attempted and some have worked well (for example, the Nordic Gene Bank and the SADCC Genebank). However, most have failed due to lack of political will or political/cultural sensitivities. In order to be able to capitalise on the advantages of shared conservation facilities and management of collections, it is critical that appropriate policies and strategies be developed and implemented at both the regional and national level. Success almost certainly depends on building trust among countries, and faith that regional facilities will be able to meet their national needs adequately. Lack of such trust is a major constraint and has been exacerbated by the increased emphasis on national control of access under the CBD. Great emphasis is placed on genetic resources as a potential national ‘treasure’ and insufficient attention has been given to the fact that a country’s staple food crop may in the future have to rely on germplasm from other countries.

For millennia, conservation has taken place not in genebanks but in a dynamic situation on farmers' fields. The growing recognition by the formal sector of the importance of sustainable development, as exemplified by Agenda 21 and aspects of the CBD, leads to the need to consider *in situ* conservation on farms as a key part of the overall strategy for conservation. A number of initiatives around the world are looking at the scientific underpinning of on-farm conservation. A range of options are being studied, from providing direct and indirect incentives for conserving traditional varieties and land races to participatory breeding approaches based on local varieties, that aim to conserve adaptive gene complexes and locally preferred traits. As more information becomes available from such studies, options that are efficient and effective for conserving alleles and/or genotypes, while meeting local farmer and community needs, should become clear.

In many parts of the world, community genebanks are being developed as a system for conserving local varieties and ensuring they remain available over time to the communities that developed them. All too often the links between such community genebanks and national and international genebanks are nonexistent or very weak. It is critical that these links be strengthened and that the two genebanks systems, formal and informal, effectively complement each other. In addition, if community conservation is to work well it must be linked to other aspects of agriculture, such as village nurseries and local seed supply systems. This has had variable success historically.

B.2.4. Phytosanitation and Quarantine

While it is widely accepted that the relatively unfettered movement of germplasm can substantially facilitate plant genetic improvement, it is essential that such movement is not accompanied by the dispersal of pests and diseases. Adherence to quarantine regulations can help to minimise the risks of spreading pests and diseases along with the germplasm. However, relatively few countries, especially in the developing world, have either adequate plant health regulations or the mechanisms to monitor and enforce them. Phytosanitary regulations need to be continually updated to take into account the latest detection and eradication methods, and should seek to achieve a balance between promoting germplasm movement while minimising the risks of spreading pests and diseases.

B.2.5. Sustained Funding

A number of political events have led to some of the world's major genebank collections being in jeopardy. Mechanisms are needed to cope with these. Before considering them, however, it is logical to consider the moral responsibilities.

Conserving plant genetic resources for the future, to help ensure food security, is clearly a collective international responsibility. On the other hand, the management of these resources for use by plant breeders and farmers is perhaps more appropriately regarded as a national responsibility, even though national interests in this regard are often best met through collective regional or international action. It could be argued that these two responsibilities need to be addressed differently, but at present this is not always the case. International conservation programmes are largely funded through Overseas Development Assistance or 'aid' funds, although there is a huge measure of self-interest in allocating funds to such activities by donor countries. While such 'aid' funds might appropriately be used to help poorer countries to develop their capacity to use genetic resources, it might be more appropriate for international conservation to be funded from sources earmarked for national activities: for example, through Ministries of Agriculture.

The GEF is a mechanism for implementing the collective international responsibility for conservation. However, its role in support of *ex situ* conservation still needs to be further defined. Loan and other financial mechanisms could be used to safeguard valuable collections in jeopardy at any one time. If these mechanisms were to be clarified and generally agreed, the roles of the donor community would become clearer. Nonetheless, these possibilities do not negate the need for individual governments to support their own endeavours.

B.3. Governance Constraints

This short appendix has identified a number of governance issues, including

(1) genebanks and their usage must relate to national policies on conservation, plant breeding, agricultural production and sustainable agriculture; such policies need to be long-term; investment in conservation today may only pay off many years hence;
(2) the CBD provides a framework for overall action but implementing parts of it puts constraints on many nations, particularly in regard to strategic planning and funding; the CBD, however, was largely negotiated by environmental ministries and may not be the ideal instrument for agricultural genetic resources—hence the importance of the ongoing negotiations within the FAO Commission;
(3) improved governance and other mechanisms are needed in relation to regional and international genebanks, to ensure they are effective and
(4) moral responsibilities for conservation, national responsibilities for production and development and clear international imperatives are still not very well defined in any forum. This hinders the rationalisation of funding mechanisms and the clarification of the roles of international agencies and bilateral donors.

B.4. The Special Role of the International Crop Genebanks

On 16th June 1994, the CGIAR issued the following statement: 'In recognition of the fundamental importance of the conservation of plant genetic resources, the Consultative Group on International Agricultural Research decided to establish a system-wide programme for plant genetic resources…'.

In the development of a system-wide programme, the CGIAR reaffirms the complementarity of *ex situ* and *in situ* conservation and recognises the critical role of science in the underpinning of all conservation strategies. It further underscores its continuing commitment to the conservation of a wide range of crops, trees, animals and other organisms, in partnership with national programmes and the international community. It stands ready to work with all governments, scientific institutions, NGOs and others committed to the conservation, exchange and utilisation of biological diversity for the benefit of all, especially developing countries. The CGIAR also reaffirms the principle that the research centres that it supports should not seek to benefit financially from the commercialisation of germplasm, but should help developing countries obtain financial benefits when opportunities occur.

Trusteeship of the CGIAR for the germplasm collections held at the various international agricultural research centres is a most serious matter for the CGIAR. In New Delhi (May 1994) the CGIAR requested its co-sponsors (FAO, UNDP, and the World Bank) '…to enter into further consultations with intergovernmental bodies leading to an agreement which will ensure that the collections held in trust by the CGIAR for the world community are properly maintained, secure in status and freely available, within an agreed policy framework. The CGIAR is committed to carrying out the responsibilities of this trusteeship in concert with FAO and its Commission on Plant Genetic Resources and with the Contracting Parties to the Convention on Biological Diversity'.

In accordance with this general policy statement, in October 1994 the CGIAR centres signed agreements with FAO placing their germplasm collections under the auspices of FAO as part of the international network of *ex situ* collections provided for in Article 7 of the IU. The centres would hold specifically designated accessions in trust for the benefit of humanity.

This agreement recognises the intergovernmental authority of FAO and its Commission on Genetic Resources for Food and Agriculture in setting policies for the network. The centres also acknowledge their traditional commitment to unrestricted availability of germplasm held in their genebanks. To keep this material available for research and further utilisation, the centres undertake not to claim legal ownership over the designated germplasm nor to seek any intellectual property rights over that germplasm or related information. Furthermore, the centres agree to pass on the same obligations to all future recipients of designated germplasm. In this sense, the recipient is required to sign a materials transfer agreement by which he agrees to (*a*) not claim ownership or intellectual property rights over the designated germplasm or related information and (*b*) ensure that any subsequent person or institution to whom the sample is transferred is bound by the same provision.

Appendix C: *In situ* Management of Genetic Resources

C.1. Introduction

Biodiversity supports a wide range of ecological services, from maintaining atmospheric quality to ameliorating climates, and assimilating waste. It also plays a key role in the smooth operation of the hydrological cycle, vital for flood control and ensuring adequate supplies of water for irrigation and drinking, as well as recycling nutrients, regenerating soils, pollinating crops, providing a rich harvest of protein from seas and rivers and, not least, offering a generous genetic library for improving agriculture (Daily, 1997). Biodiversity derives its value from the provision of these diverse and critical services, but how biodiversity is valued varies from one culture to the next. Biodiversity spans all organisation levels: from genes to species, and to ecosystems. At the level of individual agroecosystems, which encompass not only cultivated plots but also surrounding habitats that provide pollinators and water for irrigation, the most important ecological services are related to the regulation of hydrological flows, the maintenance of soil structure and nutrients, and plant reproduction.

In many ecosystems, it is possible to maintain the flow of valued ecological services under given environmental conditions over quite widely differing levels of biodiversity. That is, there is an element of redundancy in the system. In all ecosystems, however, systems fail once biodiversity levels fall below a certain critical threshold. All self-organising, living systems require a minimum diversity of species to capture solar energy and to develop the cyclic relation of fundamental compounds between producers, consumers and decomposers on which biological productivity depends. Moreover, for any ecosystem, even though the minimum level of biodiversity required to maintain the flow of valued ecological services under one set of environmental conditions may be considerably lower than the actual level of biodiversity, a change in environmental conditions can alter the mix of organisms, populations and communities needed to maintain the flow of ecological services. Biodiversity thus has value both in supporting the flow of ecological services, and in ensuring that such systems are resilient and can therefore adapt to change.

Put another way, the level of biodiversity in an ecosystem determines its capacity to respond to the stresses imposed by environmental change, such as anthropogenic pollution or harvesting. The ability of an ecosystem to cope with stress and shock is measured by its resilience. The value of biodiversity has accordingly been argued to lie in its role in protecting ecosystem resilience (Perrings *et al.*, 1995; Heywood, 1995) Although economists have long recognised that the market prices of species are poor indicators of their wider value to humanity, they have only recently begun to grapple with the problem of the valuation of biodiversity. For agro-ecosystems, data are available on the commercial benefits of specialisation (deletion of species or the reduction of genetic variation within a species) and the introduction of pests and pathogens (addition of species), but the value of maintaining future options by conserving genetic diversity has yet to be systematically measured.

One problem is that the range of species and their associated genetic variation capable of performing particular functions under different environmental conditions is not readily observable. But in many cases, the value of the loss of functional diversity may be obtained by indirect methods. In the Serengeti grasslands, for example, communities exhibiting varying species responses to a fluctuating environment tend to be most constant in terms of primary production. The same set of species are present all the time, but different species contribute to biomass at different rates depending on environmental conditions.

C.2. *In situ* Conservation of Agricultural Genetic Diversity

It is now widely recognised that *in situ* conservation of genetic resources for agricultural development is an essential component to the global effort to safeguard crop (and animal) germplasm in genebanks (see Appendix B). In the past, conservation of genetic resources has emphasised *ex situ* approaches, essentially drying and holding seeds at low temperatures or assembling collections of root and tree crops in field genebanks. While genebanks play an important role in conserving genetic resources of many crops—mainly the globally important food crops—and making them available to breeders, they have their limitations (FAO, 1998; Plucknett *et al.*, 1987). A parallel approach is now viewed as essentially using both *ex situ* and *in situ* conservation.

In situ conservation involves maintaining crops with their constellation of varieties on farms, as well as safeguarding relatively undisturbed habitats that harbour a broader array of biodiversity which performs essential services for agriculture. In their 'natural' settings, crops and their near relatives can continue to evolve, and by safeguarding wild habitats the option for domesticating new crop plants remains open. Natural habitats sometimes contain wild populations of existing crop genepools and these are a valuable resource for crop improvement. Only a small portion of the genetic variation of many crops is maintained in seed or field genebanks: *in situ* conservation therefore remains the main hope for protecting the biodiversity heritage of humankind, especially for many crops of great value in smallholder agriculture, trees of value in agroforestry, and others.

Focus on on-farm conservation and management of genetic diversity directly addresses issues raised by Agenda 21 and the CBD framework. Requirements for practical action include policy reforms, national and local strategies, and institutional changes and should be based on the following principles (Thrupp, 1998):

- to empower farmers and communities to protect their rights to resources, support their knowledge, and cultural diversity, and ensure their participation in decision making, R&D processes, and conservation efforts;
- to develop an ecosystem approach, using agro-ecology as a guiding scientific paradigm, to support and validate the sustainable use and enhancement of genetic resources and of agrobiodiversity at all levels;
- to develop policies and institutional changes that support agrobiodiversity, ensure food security and protect farmers' rights, and eliminate policies that lead to the loss and displacement of genetic diversity;
- to adapt agricultural practices and land use to local agroecological and socio-economic conditions, adjusted to local diverse needs and aspirations;
- to conserve and regenerate genetic resources and manage them in a sustainable way to include enhancement;
- to develop a framework for enhancing diversity, and work towards the integrated goals of food security, social equity and health, economic productivity and ecological integrity.

The *in situ* conservation of species in ecosystems, whether in protected areas, managed *in situ* areas or specially designed genetic reserves, would be part of an integrated approach to conservation and use of genetic diversity. Much needs to be done to create synergies between UN agencies and other international organisations in this respect and between diverse ministries in countries. Coordination requires a great deal of improvement at all levels.

C.3. Stakeholder Involvement

While most policy makers understand the importance of *in situ* conservation, insufficient attention has been paid to the long-term sustainability of such approaches. One of the surest ways to foster a commitment to *in situ* conservation is to involve the pertinent stakeholders in both the planning and implementation of policies to safeguard resources on-farm and in the wild.

Stakeholders can be separated into several categories: those involved in raising crops and livestock, private-sector companies involved in marketing produce, biotechnology companies working on 'genetic engineering' techniques to improve agriculture, consumer groups, government agencies and scientists. The concerns and aspirations of the different groups need to be systematically brought into the mainstream of policy formulation at government level.

C.3.1. Farmers, Ranchers and Pastoralists

Farmers, herders and ranchers, like smallholders, are stakeholders in the conservation of genetic diversity because their survival depends on the environmental services that biodiversity provides. Diversified farming operations, for example, provide a hedge against wild swings in commodity prices or environmental surprises such as pest or disease outbreaks.

On-farm conservation of genetic resources involves not only diverse varieties of crops and animal breeds in the fields, gardens and pastures, but also local seed stores of indigenous and rare varieties. Communities are generally involved in the maintenance and storage of indigenous crop varieties using traditional methods. Both men and women are involved in such behind-the-scenes activities that are vital to the stock of genetic diversity, yet often overlooked by development planners promoting modern varieties through credit systems that only liberate funding for approved varieties. In reality, local efforts to conserve agrobiodiversity can be highly effective, and so do not necessarily relegate communities to a backward standard of living. Both modern, high-yielding varieties and traditional cultivars can coexist as long as development planners are sensitised to the value of indigenous knowledge and local conservation and management systems.

It is often supposed that communities can manage agrobiodiversity if they have a voice in policy formulation. But communities are not always homogenous. For this reason, local participation is probably a better choice of words because it includes all the relevant actors on the ground level—from farmers, to ranchers, pastoralists, and plantation owners. The mix of land uses and the scale of operations will vary from location to location, but the point is to include all the players, not just small farmers. In some areas, growers' associations and cooperatives are logical partners in planning *in situ* conservation programmes. Recognition of the rights of farmers is embodied in the CBD and the IU (see also Cleveland and Murray (1997)).

C.3.2. Private-Sector Companies

Biotechnology companies have a stake in the conservation of biodiversity. It is sometimes assumed that dazzling feats created in biotech labs will obviate the need to safeguard nature. But the best laboratories for genetic diversity are still to be found in the field. In general, biotechnology companies do not invest in *in situ* conservation, assuming that to be the task of society at large. There are a few widely quoted exceptions. Incentive structures could be put in place to encourage more biotechnology companies to support genetic conservation.

C.3.3. Consumer Groups

Consumers can play an important indirect role in promoting *in situ* conservation of genetic resources by encouraging mainstream grocery stores to stock produce based on traditional or heirloom varieties: these are frequently fairly robust and require few if any applications of chemicals. In some developed countries, niche markets have emerged to satisfy the growing demand for novelty foods. By exploiting niche markets, farmers have an incentive to maintain varieties that would otherwise be abandoned.

C.3.4. Governments

Governments at all levels in society have a vested interest in the conservation of biodiversity, in keeping the cost of agricultural production down, and ultimately the price of food. Many nations have signed the CBD and have expressed a commitment to *in situ* conservation of genetic resources.

Government leaders have also been active in debates on the importance of conserving biodiversity and have publicly endorsed its value for future generations. Although the effectiveness of government institutions in protecting habitats for wildlife and in upholding laws designed to safeguard the environment is sometimes questioned, governments are nevertheless important stakeholders despite many inefficiencies.

C.3.5. Scientists

Many scientists working in both the private and public sector have a stake in the survival of as much biodiversity as possible to increase their options for future work. Researchers in the field of agriculture, medicine and industry increasingly use biodiversity at the molecular, species and habitat levels to further progress in their respective areas, whether it be developing genetically enhanced crops or discovering new drugs to treat old or emerging diseases. Many scientists are involved in promoting *in situ* conservation and are testing various approaches to harmonising development and environmental protection.

Researchers in some areas are forging links with local communities to revitalise traditional farming systems that are often rich in biodiversity, and there are good examples of participatory approaches: for example, in plant breeding. NGOs play an increasingly important role, especially in public education, advocacy, and in programmes for sustainable development. International NGOs, such as WWF and IUCN, play major roles in *in situ* conservation.

C.4. Reorienting Approaches to Conservation

The development of participatory approaches and empowerment requires deliberate measures, such as training, to change conventional approaches to agricultural research and development (Thrupp, 1996) and in particular genetic conservation measures. Numerous documents have been written on systematic and effective ways to increase the use of participatory approaches. The application of these approaches improves the likelihood of adoption and success of agrobiodiversity efforts.

Appendix D: Ethical Issues in Genetic Conservation

D.1. Introduction

Ethics are part of the way humans adapt to their social and environmental settings. They help to ensure that human behaviour is guided in directions that are socially appropriate and seek a balance between public and private interests that enable societies to function in their particular ecological, socio-political and historical setting. Since such settings vary, so too do ethical systems. Whereas certain ethical principles may be universal, their expression will also differ from place to place.

In designing the interrelated management of genetic diversity, biotechnology and agricultural R&D there is a need to base it on an explicit understanding of values which are promoted through different types of production systems and also by institutional arrangements.

The CBD has incorporated strong ethical positions. The three objectives of the CBD—conservation of biological diversity, sustainable use of biological resources and equitable distribution of benefits arising from the use of genetic resources—are accompanied by a series of ethical statements. In the preamble to the CBD there is recognition of 'the intrinsic value of biological diversity and its components.' The convention affirms that the conservation of biological diversity is a common concern of humanity, but that states have sovereign rights over their own biological resources. The CBD also builds into its considerations a temporal dimension, recognising that conserving and sustainably using diversity needs to benefit both present and future generations.

The ethical statements of the CBD raise some dilemmas. For instance, many indigenous people feel that they have sovereignty over the diversity in their territory, rather than the state government. Furthermore, emphasising sovereignty and access through prior informed consent on mutually agreeable terms could promote economic or commercial values of genetic resources at the cost of the common interests of humanity at large. This could result in restrictions on agricultural research rather than the promotion of the free flow of genetic materials on which plant breeders from the farm level to industry depend.

There are special cases to be considered for use of genetic diversity through biotechnology. Newer biotechnological techniques can enhance diversity through the generation of new genotypes, but can also reduce it through the promotion of a limited number of super-varieties. This has always been an issue in relation to plant breeding efforts. Where biotechnology can impact more readily is in the possible expansion of cultivation into more marginal areas, especially those habitats important for *in situ* conservation of wild species.

D.2. The Scale of Enquiry

Modern production systems employ advanced technologies ranging from chemical inputs to the incorporation of GMOs. Farmers have little control. Further, the technologies have the potential to impact irreversibly on the environment and this cannot be predicted by traditional knowledge. Use of the technologies requires explicit assessment of costs and benefits and a commitment to appropriate ethical consideration.

Civil society is likely to respond differently to the new technologies than to working at the whole plant or animal level, the latter being familiar to the general public, but the former falling into the realm of having to take the word of scientists or industry. Past experience has led to public scepticism due to numerous claims having been made which proved to be incorrect or lacking in vision. DDT and CFCs are typical examples, and GM crops might be in the same category.

Different sets of ethics may be brought into play at different levels, for instance when dealing with transnational companies, governments, or the private sector. Individuals, whether farmers or researchers, may have different ethics depending on their backgrounds. In building partnerships for conservation and use of genetic diversity the ethical values at each level need to be understood. This is extremely important when local communities are involved. Trust has to be developed whereby cultural values are recognised.

Scientific researchers and biotechnology companies are faced with possible ethical conflicts because their research results may well provide unpredictable and differential benefits to various groups and at various scales. Understanding the competing interests and values of such groups requires an understanding of social processes as well as of how genetic diversity provides different benefits to different interests.

Interdisciplinary research can be a way to ensure broader representation of ethical viewpoints. For example, aspects of law, economics and rural sociology should be built into efforts to conserve genetic diversity. In particular, for conservation to be of the greatest benefit more effort needs to be decentralised and adapted to local conditions, with operational transparency and a broad political base.

D.3. Ethical Guidelines

The following principles can act as guidelines:

- Conservation of genetic resources should be understood to incorporate sustainable use including traditional systems of conservation and management.
- Efforts to conserve genetic resources should be based on the principles embodied in the CBD, including the equitable distribution of benefits.
- Any assessments of the costs and benefits of genetic conservation should consider the distribution of benefits, in order to see flows to the disadvantaged.
- More attention needs to be given to genetic conservation designed to improve the welfare of the poorest sector of the rural population. This requires new programmes and new measures.
- In designing programmes the imperatives of the global economy must not be allowed to undermine the traditional exchange of genetic materials among farmers.
- Local farmers should participate in research programmes and their intellectual contributions should be recognised.
- Private biotechnology companies must carefully adhere to national policies. However, they would be recognised more if they prepared voluntary codes of conduct and adhered to them.
- Whereas the conditions of access as stated in the CBD will need to be carefully observed, biotechnology companies will also need to see that any field trials are done with the full knowledge and consent of local farmers.
- Scientists and commercial seed companies have the responsibility to avoid undue risk and to accept the principle of accountability.
- *In situ* conservation of genetic diversity for food security should incorporate broader biological diversity.

D.4. Development of Guidelines

Although development of guidelines has been slow at the level of international organisations, some positive steps have been taken at the national level. For instance, India has developed a Voluntary Code of Conduct for Fostering Biopartnerships (1998) which embodies the ethical principles of the CBD and the IU.

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