INDICATORS OF AGRICULTURAL GENETIC RESOURCES: FAO's CONTRIBUTION TO MONITORING AGRICULTURAL BIODIVERSITY

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Indicators of Agricultural Genetic Resources:

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Abstract

For the purpose of this session of the OECD Expert Meeting, this paper will focus particularly on indicators for plant and animal genetic resources.

Within the context of the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (GPA) and the Global Strategy for the Management of Farm Animal Genetic Resources (Global Strategy), FAO is involved in the identification of indicators for plant and animal genetic resources for food and agriculture. The Commission on Genetic Resources for Food and Agriculture, established by the FAO Conference, is the permanent governmental forum whose purpose is to discuss and negotiate matters relevant to genetic resources for food and agriculture. FAO's work on indicators contributes to the development of indicators for agricultural biodiversity within the framework of the Convention on Biological Diversity (CBD).

The development and use of indicators of *plant genetic diversity/erosion and plant genetic vulnerability* would facilitate the establishment of benchmark data and the elucidation of trends, and, ultimately, allow for improved management of plant genetic resources for food and agriculture. To this end, FAO's work on indicators is undertaken through two processes. One process is the development of indicators to monitor the Global Plan of Action, whereas the other process is to develop indicators and their use for genetic diversity, genetic erosion and genetic vulnerability, at various scales. FAO's work on *animal genetic diversity* is mostly related to domestic animals and their wild relatives, in recognition of their role in sustainable rural development and food security. Under the general framework of the Global Strategy, FAO initiated the preparation of the first country-driven Report on the State of the World's Animal Genetic Resources. FAO is also involved in the identification of criteria and indicators for fisheries and forestry.

Keywords: *plant and animal genetic resources; monitoring; indicators; agricultural biodiversity; FAO; CGRFA*

Indicators of Agricultural Genetic Resources:
FAO's Contribution to Monitoring Agricultural Biodiversity

Introduction

Although FAO is addressing biodiversity in agricultural ecosystems, the purpose of this particular paper is to present the role, as well as current and planned activities of the Food and Agriculture Organization of the United Nations (FAO) in the identification of indicators for agricultural genetic resources, and more specifically, for plant and animal genetic resources, as per the agenda of the Expert Meeting. It also presents this level of indicators in the context of the development of agricultural biodiversity indicators. This work is also intended to assist countries in their endeavour to develop indicators in line with the programme of work on agricultural biodiversity of the Convention on Biological Diversity (as per decision V/5).

Background

FAO's role in the development of agricultural genetic diversity indicators

The context within which FAO is currently developing indicators for plant and animal genetic resources is through the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (GPA)* and the *Global Strategy for the Management of Farm Animal Genetic Resources (Global Strategy)*. The Programme of Work on Agricultural Biodiversity (decision V/5) of the CBD specifically states that the overall objectives, approach and guiding principles would "build upon existing international plans of action, programmes and strategies that have been agreed by countries, in particular, the Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture, the Global Strategy for the Management of Farm Animal Genetic Resources...".

In decision III/11 of the CBD, FAO was invited to support the development and implementation of the Programme of Work on Agricultural Biodiversity. As a lead partner, FAO identified, in collaboration with the CBD Secretariat, elements for a programme of work on agricultural biodiversity, which was then discussed at SBSTTA V and adopted at COP V (decision V/5). The Programme of Work includes developing methods and techniques for assessing and monitoring the status and trends of agricultural biodiversity and other components of biodiversity in agricultural ecosystems. These include "...criteria and guidelines for developing indicators to facilitate monitoring and assessment of the status and trends of biodiversity in different production systems and environments, and the impacts of various practices, building wherever possible on existing work, in accordance with decision V/7, on the development of indicators on biological diversity, in accordance to the particular characteristics and needs of Parties" (decision V/5 programme element 1.5(a)).

Activities undertaken for the identification of indicators takes place within the context of FAO's dual role - the double role of FAO as a technical secretariat and as an intergovernmental forum allows FAO to provides technical oversight as well as policy guidance for issues related to food and agriculture including plant and animal genetic resources. FAO's objective in working towards the identification of indicators for agricultural genetic resources is to be able to identify, and assess, the extent of genetic diversity, genetic erosion, and genetic vulnerability in agricultural ecosystems.

Commission on Genetic Resources for Food and Agriculture (CGRFA)

The Commission on Genetic Resources for Food and Agriculture is a permanent forum where governments discuss and negotiate matters relevant to genetic resources for food and agriculture. Its constituency is currently composed of 160 countries and the European Union. The main objectives of the CGRFA are to ensure the conservation and sustainable utilization of genetic resources for food and agriculture, as well the fair and equitable sharing of benefits derived from their use, for present and future generations. The CGRFA aims to reach international consensus on areas of global interest, through negotiations.

Originally, in 1983, the CGRFA was established as the Commission on Plant Genetic Resources, by the FAO Conference, to deal with issues related to plant genetic resources. In 1995, its mandate was broadened to cover all components of agricultural biodiversity of relevance to food and agriculture, whereby it was then renamed the Commission on Genetic Resources for Food and Agriculture (CGRFA). The CGRFA deals with policy, sectorial and cross sectorial matters related to the conservation and utilization of genetic resources for food and agriculture, and also provides guidance for the development and assessment of progress being made in the implementation of the Global Strategy for the Management of Farm Animal Genetic Resources and the Global System for Plant Genetic Resources. In 1997, the CGRFA established two subsidiary bodies: the Intergovernmental Technical Working Group on Plant Genetic Resources and the Intergovernmental Technical Working Group on Animal Genetic Resources, to deal with specific matters in these two areas.

Plant Genetic Resources for Food and Agriculture (PGRFA)

Intergovernmental Technical Working Group on Plant Genetic Resources for Food and Agriculture

The subsidiary Intergovernmental Technical Working Group on Plant Genetic Resources for Food and Agriculture (ITWG-PGR) was established at the Seventh Session of the CGRFA, in May 1997, to address issues specific to plant genetic resources for food and agriculture. It is through the ITWG-PGR that the CGRFA monitors and coordinates the development of the Global System on Plant Genetic Resources. The objectives of the Global System are to ensure the safe conservation, and promote the availability and sustainable use of plant genetic resources by providing a flexible framework for sharing the benefits.

The two key elements of the Global System are:

a) The Report on the State of the World's Plant Genetic Resources;

b) The Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.

State of the World

The first Report on the *State of the World's Plant Genetic Resources for Food and Agriculture (PGRFA)*, presented to the Fourth International Technical Conference held in Leipzig, Germany (June 1996), was prepared through a participatory, country-driven process. It assessed the state of plant genetic diversity and capacities at the local and global levels for *in situ* and *ex situ* management, conservation and utilization of plant genetic resources.

At the First Session of the ITWG-PGR (Rome, July 2001), guidance of the ITWG-PGR was requested regarding the preparation of the second *State of the World's PGRFA*. In particular, it was proposed that the

second Report be supplemented by thematic studies. A proposal for one of the thematic studies is on indicators for measuring plant genetic vulnerability and genetic erosion (CGRFA/WG-PGR-1/01/Report).

The Global Plan of Action

One hundred and fifty countries adopted the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (GPA)* at the Fourth International Technical Conference on Plant Genetic Resources (Leipzig, June 1996). The main aims of the GPA are to: (i) ensure the conservation of plant genetic resources for food and agriculture as a basis for food security; (ii) promote sustainable utilisation of PGRFA in order to foster development and reduce hunger and poverty particularly in developing countries; (iii) promote a fair and equitable sharing of benefits arising from the use of PGRFA, recognising the desirability of sharing equitably benefits resulting from the use for traditional knowledge, innovations and practices relevant to the conservation of PGRFA and their sustainable use; (iv) assist countries and institutions responsible for conserving PGRFA to identify priorities for action; and (v) strengthen, in particular, national programmes, as well as regional and international programmes, including education and training, for the conservation and utilisation of PGRFA and to enhance institutional capacity.

The Conference agreed that "overall progress in the implementation of the GPA and of the related follow-up processes would be monitored and guided by the national governments and other members of FAO, through the Commission on Genetic Resources for Food and Agriculture". The Conference also requested the CGRFA to "set the formats for receiving progress reports from all the parties concerned and establish criteria and indicators to assess progress" in the implementation of the GPA.

At its Seventh Regular Session in May 1997, the CGRFA considered follow-up and requested "that FAO play a proactive and creative role in facilitating and monitoring the implementation of the *Global Plan of Action*", and agreed to develop a transparent and efficient monitoring process, recommending that within the framework of the priority activity areas of the GPA a core set of indicators should be established to facilitate such a process.

Framework of Indicators for PGRFA

Within FAO activities related to plant genetic resources, work on indicators is currently being undertaken under two interlinked processes:
(A) Assessment of the state of the world's plant genetic resources; and
(B) Monitoring the implementation of the Global Plan of Action.

<u>Process A</u>
The objectives of process A are (a) to review the "state of the art" of indicator development and use for genetic diversity, genetic erosion and genetic vulnerability, at various scales, including a feasibility study of assessing genetic diversity/erosion at the national level; and (b) to develop proposed indicators to be used in second and subsequent *Report on the State of the World's Plant Genetic Resources for Food and Agriculture*. Discussions on proposed indicators arising from the OECD Expert Meeting will be considered in the FAO process.

The development and use of indicators of plant genetic diversity/erosion and plant genetic vulnerability would facilitate the establishment of benchmark data and the elucidation of trends, and, ultimately, allow for improved management of PGRFA. Such higher-order indicators would also eventually be incorporated into the format for monitoring implementation of the Global Plan of Action, and improve early warning of threats to plant genetic diversity. These will contribute to the implementation of the GPA, especially for those activities related to *in situ* conservation and development, sustaining *ex situ* collections, the

utilization of plant genetic resources, and constructing information systems and developing early warning systems for plant genetic resources.

Process B
At the First Session of the ITWG-PGR (Rome, 2-4 July 2001), guidance was requested with regards to a proposed set of indicators for monitoring the implementation of the GPA. In response, the ITWG-PGR considered that the proposal on indicators (CGRFA/WG-PGR-1/01/3) provides the basis for further work, and suggested:

- to review them in the light of the "driving-force state response" model framework;
- to identify a core set of indicators; and
- to develop higher-order indicators (such as those for genetic diversity, genetic erosion and genetic vulnerability)which, where feasible, should be derived from existing indicators.

Some examples of the proposed core indicators include number and kind of threatened and endangered species relevant to food and agriculture; number and kind of wild crop relatives and wild food plants for *in situ* conservation in National Environmental Action Plans; number and kind of protected areas for *in situ* conservation; number of *in situ* conservation sites and wild species conserved; number of species and accessions preserved *ex situ*, medium and long-term; degree of genetic integrity of accessions preserved *ex situ*, and list of major environmental constraints to *ex situ* conservation of PGRFA.

A reporting format for monitoring GPA implementation based on indicators will be used by national PGRFA stakeholders to collect information which will be made available under the FAO World Information and Early Warning System on PGRFA (WIEWS).

Linkages between processes
Over time, the two processes will converge, as the higher-order indicators being developed under process A can be applied to assessing the ultimate impacts of implementing the GPA (Process B). In addition, under both processes, work is taking into account capacity at national and international levels as well as the need to ensure linkages with the development and use of indicators in the Convention on Biological Diversity and other processes such as the Commission on Sustainable Development (CSD) and the Organization for Economic Cooperation and Development (OECD).

Examples of Indicators for PGRFA

Indicators of plant genetic resources can be developed to reflect diversity at the levels of the species, variety and gene, and at different spatial scales: site/field; ecosystem/landscape; country/region; and finally globally.

Examples of potential indicators are:

For diversity in use:
- Number of crop species contributing to W% of agricultural output; X% of diet; Y% of trade etc.
- Number of varieties of crops in regular use.

For genetic erosion:
- occurrence of landraces
- population diversity of landraces
- spreading of modern varieties

For genetic vulnerability:

- Relative areas sown to different cultivars and extent of genetic relatedness between these cultivars.

At the gene pool level, the degree of diversity used (inverse of potential vulnerability) can be assessed according to a number of criteria and indicators which are developed in Cooper et al. (2001). This could also be looked at the gene level, i.e. the uniformity of resistance genes in a crop.

Animal Genetic Resources for Food and Agriculture (AnGR)

Background

At the Seventh Session of the Commission of Genetic Resources for Food and Agriculture (CGRFA) in May 1997, a subsidiary Intergovernmental Technical Working Group on Animal Genetic Resources (ITWG-AnGR) was established to address issues relevant to the conservation and sustainable use of animal genetic resources for food and agriculture. During the First Session (8-10 September 1998), the ITWG-AnGR considered issues relating to the development of the *Global Strategy for the Management of Farm Animal Genetic Resources*, including the preparation of the first *Report on the State of the World's Animal Genetic Resources*. During its Second Session (September 2000), the ITWG-AnGR reported on the progress of the development of the Global Strategy, as well as the preparation of the first *Report on the State of the World's Animal Genetic Resources.* This session fully supported the preparation of the first country, regional and global assessment of animal genetic resources and further detailed the SoW-AnGR process and follow-up mechanism. It specifically requested that countries, donors, stakeholders and FAO, increase efforts to mobilize the resources necessary, including financial resources, to prepare Country Reports, build capacity to successfully undertake the actions necessary to prepare the first *Report on the State of the World's Animal Genetic Resources* and implement priority follow-up actions.

Global Strategy for the Management of Farm Animal Genetic Resources

The Global Strategy for the Management of Farm Animal Genetic Resources provides a framework for local, national, regional and global efforts to make better use of, develop and conserve these resources. More specifically, the Global Strategy is comprised of:

- an intergovernmental mechanism for direct government involvement and policy development;
- a country-based global infrastructure to help countries cost-effectively plan, implement and maintain national strategies for the management of animal genetic resources;
- a technical programme aimed at supporting effective action at the country level in the sustainable intensification, conservation, characterisation and access to Animal Genetic Resources; and
- a reporting and evaluation system to guide the Strategy's implementation, facilitate collaboration, coordination and policy development and maximize cost-effectiveness of activity. The reporting system will be the vehicle through which to implement the Global Strategy, and is the *Report on the State of the World's Animal Genetic Resources* (SoW-AnGR). Currently, the main focus of the Global Strategy is on the SoW-AnGR process.

State of the World's Animal Genetic Resources (SoW-AnGR)

The first Report on the State of the World's Animal Genetic Resources will be preceded by the Strategic Priority Actions Report. The Strategic Priority Actions Report will identify both capacity building requirements and specific needs for urgent action, and provide a basis for the ITWG-AnGR and the Commission to consider an appropriate implementation mechanism to ensure action on the strategic findings. Presentation of this Strategic Priority Actions Report in 2003 will provide governments with a basis to further develop and elaborate the first Report prior to its completion in 2005, and will provide the foundation for governments and organizations to respond to high priority areas of common interest and

concern. The Strategic Priority Actions Report will also assist in the further development and implementation of the Global Strategy.

The SoW-AnGR Report will provide a foundation for setting country, regional and global priorities and programmes and for developing cooperation and assistance in maintaining and enhancing the contribution of animal genetic resources to food and agriculture. The outcomes sought by the SoW-AnGR process, include: (i) assessing national and regional capacity to manage animal genetic resources, and facilitating priority-setting *inter alia* for training and technology transfer and other forms of capacity-building; (ii) providing the CGRFA with comprehensive data and information on the state of animal genetic resources, as a basis for policy and management development in this sector, identifying gaps and opportunities and thereby providing a foundation for establishing priorities for country, regional and global action; (iii) increasing awareness of the many roles and values of animal genetic resources in order to promote action aimed at the better use, development and conservation of these essential resources; (iv) promoting informed planning and collaboration among governments, non-governmental organizations and experts involved in the management of animal genetic resources; and (v) improving understanding of the status of breeds and of wild relatives of domesticated animals that are at risk, thus providing a foundation for an Early Warning System for Animal Genetic Resources.

The First SoW-AnGR Report will be based on Country Reports, which are envisaged as strategic documents, analysing state of the countries' animal genetic resources and state of capacities for their management ("where we are") setting the vision for future developments ("where we need to be") and providing priorities for action ("how to achieve our goals"). The Country Report preparation is seen as a participatory process, involving the contribution of animal genetic resources stakeholders, and leading to policy and capacity development.

Activities related to the development of indicators for animal genetic resources

To date, FAO has not packaged a specific set of indicators for animal genetic resources, nonetheless, a number of important and key activities are being undertaken, contributing directly to indicators of animal genetic resources, to monitor the state of their genetic diversity, erosion and vulnerability. In addition, indicators have been identified for the purpose of monitoring the Global Strategy. FAO's activities on indicators for animal genetic resources are listed below:

DAD-IS, the Domestic Animal Diversity Information System, is an internet-based system for countries to collate, store and access information on animal genetic resources (http://www.fao.org/DAD-IS). A special SoW-AnGR module of the DAD-IS system is created specifically to assist countries in the preparation of Country Reports. *The DAD-IS system would allow for the development of indicators (such as for risk status) at the national level, and provide an overview of those developed by countries themselves.* Indeed, input from the DAD-IS system assists in the development of the World Watch List for Domestic Animal Diversity.

The World Watch List for Domestic Animal Diversity is the voice of the Global Early Warning System for Animal Genetic Resources (FAO) which aims to prevent the erosion of and to encourage the more effective use of farm animal genetic resources. For example, over 6 300 mammalian and avian domestic breed populations recorded by 180 countries together with their wild relatives, newer domesticants and related feral populations are listed and described. The levels of endangerment of domestic animal breeds assist the monitoring of animal genetic resources important to food and agriculture. Outcomes of the analysis show a very large and increasing number of breeds are at high risk of loss, the vast majority of these at risk have no established conservation activity or related policy, and breed extinction rates are increasing. *The World Watch List for Domestic Animal Diversity plays a role in the development of indicators of the status of animal genetic resources.*

In January 1998, a meeting of experts was convened in Armidale, Australia to *develop a set of criteria and indicators that can be used to characterise diverse livestock production environments in order to better understand the comparative adaptive fitness of different breeds of the farm animal species*. The meeting was conducted to initiate the development of the necessary descriptors required for inclusion in an expanded Breeds Database in Stage 2 of the Domestic Animal Diversity Information System (DAD-IS) as requested by countries. This work also supports the further development of the Global Strategy for the Management of Farm Animal Genetic Resources. At the outcome of the meeting, five criteria had been identified (climate; terrain; disease, disease complexes and parasites; resource availability; and management interventions). For each criterion, a set of indicators was identified to better characterise these production environments. For example, under the criterion "terrain", two indicators are soil quality (surface/substrate and average slope), and altitude (mean and range).

With regards to the Global Strategy, in 1998, the meeting of the Informal Panel of Experts on the Development of the Global Strategy for the Management of Farm Animal Genetic Resources agreed to the proposed framework which identified a set of criteria and indicators to measure progress in further developing and implementing the Global Strategy. Seven criteria were identified, and under each criterion is a set of indicators. Examples of criterion include the sustainable use of animal genetic resources and the conservation of animal genetic resources. The indicators for these criterion measure, for example, the status of breed characterisation activities, breed-monitoring programmes, breeding strategies, and breed-baseline studies.

Frameworks for the Development of Indicators Related to Other FAO Activities in Agriculture

Fisheries

In the fishery sector (including aquaculture and culture-based fisheries), FAO is involved in promoting the application of genetic principles to sustainable fishery and aquaculture development. The primary mechanism to accomplish this is the FAO Code of Conduct for Responsible Fisheries that sets out in general terms that genetic diversity should be protected and conserved. The promotion of genetic indices and species indices that reflect the diversity of a population, a group of farmed fish, a community, or an ecosystem is an important aspect of FAO's normative activity.

Generally, awareness is promoted through production of scientific publications, e.g. FAO Fishery Technical Papers, FAO Meeting Reports, academic journals, and through international meetings and workshops. FAO recently published a book on inland fisheries that describes genetic indices such as heterozygosity estimates, effective population size, and population sub-division estimates, and species diversity indices such as species richness and index of endemism (Welcomme, 2001). Inbreeding indices, heterozygosity estimates, and effective population size have also been described as to their use in managing farmed fish and fish stocked into the wild in several FAO publications[1].

Indicators are crucial to risk/benefit analysis. FAO Fisheries is working with partners, primarily International Center for Living Aquatic Resources Management (ICLARM) and the Network of Aquaculture Centers in Asia (NACA) to organize workshops to determine how best to evaluate the risk of using genetically improved or alien species[2]. Fisheries plans to continue to promote the use of genetics in fishery development and help develop practical means for developing areas to use these indices in monitoring and assessment programmes.

Forestry

Over the years, FAO has served as Task Manager within the UN System to support follow-up to the recommendations of the United Nations Conference on Environment and Development (UNCED) and the subsequent, high-level forest policy dialogue, with special reference to commitments taken within the framework of the "Forest Principles"[3].

As is known, forests and trees provide a wide range of wood and non-wood products and socio-cultural services. Developments in forest management over the past decade have focused on progressing towards sustainable forest management in accordance with the "Forest Principles". The corresponding, widened sustainable forest management concept, which balances economic, environmental and social objectives of forest management, has stimulated changes in policy and legislation and in forest management practices in many countries. The recently concluded Forest Resources Assessment 2000 (FRA 2000, the full report of which can be found at: http://www.fao.org/forestry/fo/fra/main/index.jsp), coordinated by FAO, highlighted the urgent need to widely implement sustainable forest management practices to safeguard the renewability of forest resources which, if wisely managed, can be *used* without ever being *used up*. While FRA 2000 did not attempt to estimate the total area of forests under sustainable forest management world-wide, it included information on selected indicators demonstrating national level commitment to working towards sustainable forest management.

One measure of political commitment to the concept of sustainable forest management is the number of countries currently involved in international initiatives to develop and implement *criteria and indicators* for sustainable forest management. Presently, more than 150 countries are involved in a total of nine eco-regional or regional initiatives or processes established within the past ten years, within which criteria and indicators are identified, tested and implemented at national and forest management unit levels.

Among the criteria identified by all on-going processes, the criterion on biological diversity and corresponding indicators are of special interest to the OECD meeting on agri-environmental indicators. This criterion has been globally endorsed on the understanding that the continued ability of forest trees to provide products and services and to safeguard ethical, esthetic, cultural and religious values, will depend on the maintenance of forest biological diversity and the wise management of forest genetic resources.

A compilation of criteria and indicators for sustainable forest management, which have been developed within the above processes, is available at the FAO Forestry Department - Forest Resources Division Working Paper FM/5 (FAO, Rome 2001). Field assessment guides have been developed within most processes, including the dry-zone Africa and the Near East processes (available from FAO, Rome). For additional information, see: http://www.fao.org/forestry/Forestry.asp .

Other indicators

The Economic and Social Development Department of FAO is currently undertaking activities related to agri-environmental indicators. A Handbook is currently being prepared, that will provide guidelines for collection of data and concepts and definitions of important variables that are required for compilation of the agri-environmental indicators. The indicators listed in this Handbook will require adequate testing at the country-level and sub-country level before they can be used for wider application. Moreover, insofar as developing countries are concerned, the relevant data must be refined and co-ordinated to ensure the required monitoring of the environmental conditions and the computing of the related indicators. FAO is also in the process of developing a framework and indicators of the socio-economic aspects of agricultural biodiversity.

Indicators for Biodiversity in Agro-Ecosystems

Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agro-ecosystem necessary to sustain key functions of the agro-ecosystem, its structure and processes. This includes:

- Genetic resources of harvested crop varieties, livestock breeds, fish species and non-domesticated ("wild") resources within field, forest, rangeland and aquatic ecosystems; and
- Biological diversity that provides ecological services such as nutrient cycling, pest and disease regulation, pollination, maintenance of local wildlife, watershed protection, erosion control, climate regulation and carbon sequestration.

Agricultural biodiversity can be monitored and assessed at three different levels: genetic, species and ecosystem. One way of monitoring agro-ecosystems is through information gathered with the use of indicators for genetic and species-level resources (e.g. crop varieties, their abundance, their distribution, etc), which in turn would provide valuable information regarding the interaction between these, and other ecosystem functions within the agro-ecosystem. For example, a noted decrease in the abundance of a given pollinator (genetic/species level) could suggest a possible reduction in the abundance of a particular plant species (ecosystem functions/interactions). Therefore, the utilization of "functional" indicators provide information on ecosystems, but more importantly, the functions of, and interactions between, inhabitants of the given agro-ecosystem.

FAO is now looking at biodiversity in agro-ecosystems in a broader context in response to:

(i) its own needs in house working towards integrated production systems that builds upon previous work in, *inter alia*, IPM, conservation agriculture/minimum tillage, as well as work on crop and livestock genetic resource management; and
(ii) its contributions to the CBD programme of work, and requests from FAO's intergovernmental fora (CGRFA and its ITWG/PGR) to collaborate in its work on indicators with CBD, CSD, and OECD.

Within agricultural ecosystems, indicators of biodiversity can be developed at various levels:

1. Crop genetic resources and livestock genetic resources (see earlier discussions).

2. Associated diversity at field level. Even in monocultures of a single variety, there may be large amounts of associated biodiversity. For example, high-productivity intensive tropical rice production can be managed to support a wide diversity of natural enemies of insect pests, and in turn, other arthropods and other organisms (Settle et al. 1996). Indicators may be direct (such as estimates of arthropod types by Farmers Field School practitioners (see www.communityipm.org) or indirect (such as use of agrochemicals which may be a good proxy though not without complications (OECD, 2001). Similarly, in other systems, soil biodiversity may be important, especially under conservation agriculture (again the OECD indicators may be relevant, though it should be noted that organic matter levels are regarded as insensitive to change).

3. Diversity at the landscape or farming system level. This may be particularly important in supporting associated biodiversity (Settle et al 1996) and aspects of wild biodiversity (e.g.: song birds; wild-flowers, both indicators easily understood by the general public).

Next Steps

Identifying indicators for monitoring and assessing the status and trend in biodiversity in different production systems is not an easy task. For genetic resources for food and agriculture, FAO is working

within the framework of the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food And Agriculture* and the *Global Strategy for the Management of Farm Animal genetic Resources*. This work on indicators for agricultural genetic resources is linked to the development of the broader context of monitoring agricultural biodiversity.

Much work needs to be done on indicators at genetic, species and ecosystem levels. Considering existing work, including that of OECD and others, as well as the results of discussions at the OECD Expert Meeting, FAO:

1. Will be holding an expert consultation in February 2002 on monitoring the implementation of the GPA.
2. In collaboration with the International Plant Genetic Resources Institute (IPGRI), will further work on developing indicators for genetic diversity/erosion and genetic vulnerability in crops.
3. Will hold an expert consultation in 2002 to further the development of agricultural biodiversity indicators, which will assist countries in their endeavour to develop indicators and hence contribute to the CBD's programme of work on agricultural biodiversity. The discussion will focus on ecosystem services.

FAO's work on indicators for agricultural biodiversity is a process that aims at addressing the needs of its member countries, taking into account different agro-ecosystems (e.g. tropical ecosystems), as well as the different socio-political and economic conditions.

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Notes

[1] Bartley, D.M. and R.S.V.Pullin. 1999. Aquatic genetic resources policy. Pages 1-16 in R.S.V.Pullin, D.M. Bartley and J. Kooiman (eds), Towards Policies for Conservation and Sustainable Use of Aquatic Genetic Resources. ICLARM Conference Proceedings 59, Manila. Bartley, D.M. 1996. Conservation of biological diversity in hatchery enhancement programmes. In *Biodiversity, Science and Development. Towards a new partnership* (Ed. By F. di Castri & T. Younès), pp. 424-438. CAB International, Oxon, UK and IUBS, Paris, France. Tave, D.1999. Inbreeding and Broodstock Management. FAO Fisheries Technical Paper 392. Rome, Italy. Tave, D. 1996. Selective Breeding Programmes for Medium-sized Fish Farms. FAO Fisheries Technical Paper 352. Rome, Italy

[2] For example, 6th meeting of the International Network for Genetics in Aquaculture, May 2001, Hanoi; an expert consultation on genetic risk assessment is planned for Nairobi, February, 2002.

[3] The full name is the Non-Legally Binding Authoritative Statement on Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forest.