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AD HOC TECHNICAL EXPERT GROUP ON
INDICATORS FOR ASSESSING
PROGRESS TOWARDS THE 2010
BIODIVERSITY TARGET
Montreal, 19-22 October 2004
Item 3.2 of the provisional agenda*

INDICATORS FOR ASSESSING PROGRESS TOWARDS THE 2010 TARGET: TRENDS IN GENETIC DIVERSITY OF DOMESTICATED ANIMALS, CULTIVATED PLANTS, AND FISH SPECIES OF MAJOR SOCIO-ECONOMIC IMPORTANCE

Note by the Executive Secretary

1. In September 2002, the International Plant Genetic Resources Institute (IPGRI) and the Food and Agriculture Organization of the United Nations (FAO) held an expert consultation on the "Review and development of indicators for genetic diversity, genetic erosion and genetic vulnerability (GDEV)". The consultation took into account the work of the Commission on Genetic Resources for Food and Agriculture (CGRFA) in developing a set of core indicators to monitor implementation of the Global Plan of Action on the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture.

2. In 2002 at its ninth session, CGRFA suggested that "higher order indicators" be developed. The CGRFA also stated that "such higher order indicators would facilitate a more general analysis of the state of genetic resource conservation and use, and the sharing of such information with other forums, including the Convention on Biological Diversity, the Commission on Sustainable Development and the Organisation for Economic Co-operation and Development."

3. To facilitate the work of the AHTEG, the Executive Secretary is circulating herewith the report of the FAO/IPGRI expert consultation on the "Review and development of indicators for genetic diversity, genetic erosion and genetic vulnerability (GDEV)". The document is reproduced in the form in which it was received by the Secretariat.

* UNEP/CBD/AHTEG-2010-Ind/1/1.

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"Review and development of indicators for genetic diversity, genetic erosion and genetic vulnerability (GDEV): Summary report of a joint FAO/IPGRI workshop (Rome, 11-14 September, 2002)"

This document has been put at the disposal of the Ninth Regular Session of the Commission on Genetic Resources for Food and Agriculture by the Seed and Plant Genetic Resources Service

Background

In line with the recommendation of the Intergovernmental Technical Working Group on Plant Genetic Resources for Food and Agriculture (ITWG/PGR) indicators of genetic diversity, genetic erosion and genetic vulnerability are to be developed for use in the second Report on the State of the World's Plant Genetic Resources for Food and Agriculture. The development and use of such indicators will facilitate the establish of benchmark data and the elucidation of trends, and, ultimately, allow for improve management of PGRFA.

This document provides a summary report of an informal expert consultation organized jointly by FAO and IPGRI and held in Rome, 11 – 14 September 2002, to review and develop indicators of genetic diversity, genetic erosion and genetic vulnerability. It should be considered as a report of work in progress.

Participants from various regions of the world and attending in their personal capacity, were drawn from international organizations, government agencies, research organizations, non-government organizations and the private sector. 1/ The workshop examined a number of technical issues relevant to genetic diversity, genetic erosion and genetic vulnerability (see Annex 1), and reviewed relevant ongoing initiatives in other international fora, including the Convention on Biological Diversity and the Organisation for Economic Cooperation and Development, as well as complementary FAO-led initiatives such as the monitoring of the implementation of the Global Plan of Action for the conservation and sustainable use of PGRFA.

The workshop reviewed the rationale for the use of indicators, the criteria for good indicators, and the three concepts of genetic diversity, genetic erosion and genetic vulnerability, and prepared technical advice concerning indicators at three levels:

- Indicators that may be used at site level (farm; in situ project; ex situ facility), primarily for use by managers;
- Indicators that may be used at national level, primarily for use by national policy makers but also that may be incorporated into the preparatory process for the second Report on the State of the World's Plant Genetic Resources for Food and Agriculture;
- Indicators that may be used at global level to provide a summary assessment of the state of genetic resource use of certain crops, primarily for use by the Commission on Genetic Resources for Food and Agriculture.

Findings of the workshop

Rationale for the use of indicators

There is an increasing amount of data available on plant genetic resources, their state of conservation and use, and the pressures upon them. However, it can be very difficult to assimilate and interpret such information in a way that is useful in guiding management or policy decisions. Managers of plant genetic resources (e.g.: genebank curators, managers of *in situ* conservation projects, etc.) and policy makers alike need access to clearly presented information that can help them in making informed decisions. Indicators can be useful in this regard, and also in facilitating the setting of easily understood targets.

1/ Brown, Anthony; Gai, Junyi; Guarino, Luigi; Parris, Kevin; Pham, Jean Louis; Ramirez, Marleni; Reeves, James; Sangaré, Abdourahamane; Smith, Stephen; Subedi, Anil; as well as participants from FAO and IPGRI

An indicator is a summary measure of a significant physical, biological or socio-economic factor, presented in suitable form, that can assist managers and/or policy makers in monitoring progress towards a target, or in providing an early warning of a problem.

Indicators may simply be actual data or measurements of a significant factor (for example, the percentage concentration of CO_2 in the atmosphere), be derived from data using a simple calculation (for example, Gross Domestic Product), or be obtained through a more complex formula or model (for example, the Human Development Index). An indicator may be a direct measurement of the factor of ultimate interest, or a more easily measured proxy or surrogate (for example, the UK Department of the Environment uses the number of farmland bird species as an indicator of biodiversity in agricultural areas). In some cases the indicator is a measure of the driver or cause of change, rather than of the factor of ultimate interest (for example, $\%[CO_2]$ is a more sensitive, responsive and easily measured indicator than global temperature or sea level).

Criteria for indicators

An ideal indicator should be scientifically valid, clear in its meaning to non-specialists, and feasible to measure or derive. Where possible, indicators should be derived from existing data rather than require the collection of new data.

Descriptions of the concepts

The Workshop examined indicators for three inter-related concepts: for genetic diversity, genetic erosion and genetic vulnerability, on the basis of the following working descriptions:

- **genetic diversity (GD)** comprises the total genetic variation present in a population or species, in any given location. It can be manifested in different phenotypes and their different uses. It can be characterised by three different facets: (1) *numbers* of different entities (e.g.: the number of varieties used per crop; the number of alleles at a given locus); (2) *evenness* of the distribution of these entities, and/or (3) the *extent of the difference* between the entities (as in the case of pedigree date, for example).

- **genetic erosion (GE)** is the loss of genetic diversity, in a particular location and over a particular period of time, including the loss of individual genes, and the loss of particular combinations of genes such as those manifested in landraces or varieties. It is thus a function of change of genetic diversity over time. 2/

- **genetic vulnerability (GV)** is the condition that results when a widely planted crop is uniformly susceptible to a pest, pathogen or environmental hazard as a result of its genetic constitution, thereby

2/ Consistent with this, the Technical Meeting on the Methodology of the World Information and Early Warning System on Plant Genetic Resources, Prague, 1999, suggested the following definition of genetic erosion: "a permanent reduction in the number, evenness and distinctness of alleles, combinations of alleles, of actual or potential agricultural importance in a defined geographical area". In addition, the Meeting recognized that any definition of genetic erosion must be cognisant of different levels of diversity. "Combinations of alleles" should thus be taken to apply at all levels, including gene, genotypes, populations, species and ecosystems. Cultural and other socio-economic variation is pertinent. Distinctness is understood in different terms at different levels, e.g. as genetic distance or taxonomic divergence. "Evenness" is a measure of the frequency distribution of entities. Further it has been suggested (Guarino, "Approaches to measuring genetic erosion" Paper for the Prague technical meeting, 1999), that, in practice, genetic erosion may be measured as the "permanent reduction in richness or evenness of *common localized alleles* or the loss of combination of alleles over time in a defined area", since widely found alleles are under no risk, while the maintenance of common rare alleles cannot be guaranteed.

creating a potential for widespread crop losses. It may be measured at the level of a genepool, or a geographical area. It is a function of genetic diversity and its distribution in space. 3/

Identification of potential indicators

A list of potential indicators was discussed under the following areas:

Number and share of species used

Potential indicators in this group might include:

- Number and share of main crops
- Total number and listings of all species used for food and agriculture, including crop wild relatives
- Total number and listings of endangered neglected and under-utilized species (crops, and harvested wild)

These indicators could be applied at all levels, and are especially relevant at the national level.

Number and share of crop varieties

Potential indicators in this group might include:

- Total number of crop varieties ("distinct entities") per crop that are available to farmers in the locality/country/world (i.e. registered varieties and farmer named varieties)
- Share of major varieties in total production for individual crops
- Genetic differences among top varieties (by pedigree, or direct genetic measures)

These indicators could be applied at all levels, and are especially relevant at the national level.

Endangered varieties; genetic erosion

Potential indicators in this group might include:

- Numbers of varieties endangered
- Potential genetic erosion (proxy indicators)

These indicators can, in principle, be applied at all levels, though data is rarely comprehensively available.

Dynamics of diversity on farm (traditional systems); farmer management and traditional knowledge

Potential indicators in this group might include:

- Seed system and varietal dynamics:
- Farmer management and varietal selection;
- Security of traditional knowledge:

These indicators are applicable to the site or production system level. Data is available only in specific cases.

Dynamics of diversity on farm and in reserve (modernized systems)

3/ It is important to note that this third concept address the vulnerability of loss of genetic resources, which is an aspect of genetic erosion, but rather the potential for production loss usually due to biotic or abiotic stresses, to which the crop is not adapted. It is likely that vulnerability increases as uniformity increases. It can be considered to be related to temporal as well as spatial diversity, and thus encompass aspects of adaptability as well as adaptation. It could also be possibly used in a wider sense, to describe the vulnerability of the crop production system due to lack of genetic adaptation or adaptability.

Potential indicators in this group might include:

- Genetic Base
- Turnover of varieties
- Breeding and genetic enhancement activity

These indicators are applicable to the production system, on a crop by crop basis.

Variation in use and environmental amplitude

Potential indicators in this group might include:

- Environmental amplitude
- Number of uses of varieties.

These indicators can, in principle, be applied at all levels, though data is rarely comprehensively available.

***Ex situ* collections**

Potential indicators in this group might include:

- Total number of PGRFA accessions conserved Ex situ
- Total number of crop varieties and wild relatives ("distinct entities") per crop conserved ex situ
- Representiveness / coverage of collections for crops by country; crops, globally; or for country
- Security of each collection (conservation conditions, safety duplication & regeneration status)
- Accessibility and ease of use of the collection (completeness of information and documentation)
- Availability (i.e. whether or not in Multilateral system and/or international network, and/or otherwise freely available)

These indicators are applicable to the unit of the collection (i.e. by crop and facility, and could be aggregated to the facility, to the national genebank system, or to the crop, globally))

These potential indictors are further described in Annex 2, noting for each:

(i) particular parameters to be recorded

(ii) the usefulness and relevance of each in indicating aspects of genetic diversity, genetic erosion and genetic vulnerability;

(iii) the feasibility of employing each, including consideration of the availability of data;

(iv) issues related to the scale at which the indicator can be applied (site, crop, country) and/or aggregated; and

(v) any outstanding issues.

It was proposed that the indicators for use at national level be tested in a number of countries, to refine the methodology, ascertain the feasibility of data acquisition and confirm the usefulness, or otherwise, of the proposed indicator.

Considerations for the application of indicators

It is understood that the relevance of particular indicators depends, to a degree, on the type of agricultural system to which is to be applied: the situation will be different in the more "traditional" agricultural systems that tend to prevail in economically isolated situations or under more complex or difficult

environmental conditions, from the more "industrial" agricultural systems characteristic of higher-potential areas. While there is no absolute dichotomy between such "traditional" and "industrial" systems, it can be useful, conceptually, to examine the relevance of indicators of genetic diversity, genetic erosion and genetic vulnerability to these two idealised systems.

In traditional systems there is often a high degree of diversity between and within crops (the balance between inter- and intra-varietal diversity being determined largely by the breeding system). Nearly all seed is saved on-farm, or within the community, and the use of modern varieties is relatively low. Diversity may be important to the farmer for three groups of reasons:

- it supplies different use- needs and meets different agro-environmental requirements (adaptation);
- it is a source of variation for evolutionary change (adaptability)
- it can provide insurance against short-term environmental changes and biotic stresses

The number of varieties in the production system is therefore a significant indicator. Genetic erosion – e.g.: the loss of varieties, or traits – may have serious consequences for the livelihoods of the farmer.

By contrast, in industrial systems, diversity on-farm is usually much reduced. Most varieties are the products of formal plant breeding, and diversity on-farm is correspondingly less important to the farmer, since market integration and better environments reduce the need for multiple varieties and crop evolution is handled by the professional plant breeder rather than the farmer. The availability of a stream of new varieties may be more significant than the number of varieties in production at any one time. Genetic erosion is only a concern in centres of diversity undergoing intensification, and then, predominately from a conservation perspective. Genetic vulnerability may be a concern however, where large areas are planted to a few similar genotypes.

It is recommended, that the type of agricultural system is kept in mind as indicators are developed and used.

Possible development of composite indicators

In most cases, simple indicators have been proposed by the workshop. These have the advantages of being easier to explain to policy makers and the general public, and of being more robust, scientifically. However, in two particular cases, it was suggested that composite indicators be developed.

Firstly, it was suggested that a composite indicator of the security of genebank collections be constructed. This would comprise measurements or indications of several inter-related aspects of security, viz.:

- the type of facility and storage conditions: conventional low-temperature, low-humidity seed-banks would be regarded as affording more security than field genebanks or botanical gardens, and long term storage conditions would be regarded as affording more security than short –term conditions.
- the schedule and management of regeneration: collections that were up-to-date as regards regeneration needs would be regarded as more secure than those with a large backlog; and
- the degree of planned and documented safety duplication of collections. Duplicated collections would be regarded as having higher security than non-duplicated ones.

It was proposed that the optimum formulation of such a composite indicator be further examined by technical experts, and refined, making use of modelling techniques to predict the behaviour of the indicator under various scenarios. The refined indicator could then be tested on a few collections and in a few countries.

Secondly, it was suggested that the potential for the use of a composite indicator of plant genetic diversity for food and agriculture, in a country, based on a "basket of species" selected to be representative of various categories of plant genetic resources, including staple crops, other food species, and species used for feed, fibre or cash, and including both major crops (that are used or produced by the majority of the population of the country) and minor species (crops, or wild harvested, are used or produced by a

minority of the population of the country, including by vulnerable groups). By including information on the status of neglected and under-utilized species, the picture of the state of diversity of this "basket of species" would complement indicators of the state of diversity in major crops. The species would be selected on a country-by-country basis. The following scheme (Table 1) might be used to guide the selection of indicator species:

Table 1: Guide to selecting of indicator species

	Staples (main source of macronutrients)	Other food (important sources of micronutrients)	Cash / Fibre / Feed-forage
Used/produced by a large proportion of the population	Two major staple crops (e.g.: one cereal one root crop, or one grain legume)	Two major fruit and vegetable crops	Two major cash crops, fibre crops or forage crops
Used/produced by a large proportion of the population, including vulnerable groups	Two minor staples (cultivated or wild harvested)	Two minor fruit and vegetable species (cultivated or wild harvested)	Two minor species cultivated or harvested for cash or fibre or used as feed/forage

As far as is possible, the status of species selected should be indicative of other species in the same category, and, once this criterion has been met, those species for which more information is available might be preferred (taking care to ensure that this does not bias the selection away from under-utilized species). As far as possible, the selected species should include a balance between in-breeders, out-breeders and clonally propagated crops. Further work would be needed to refine such criteria and to design the optimal way of constructing the indicator.

A similar global "basket of species" could also be constructed (perhaps based on a somewhat larger number of species).

Possible future steps

It was considered that the work of the informal expert group provided a step towards the review and development of indicators for genetic diversity, genetic erosion and genetic vulnerability. The process of identifying and developing indicators would continue, in the context of the preparatory process for the second report on the State of the World's PGRFA, and closely linked to the activities of FAO and IPGRI to monitor implementation of the Global Plan of Action. Close collaboration with other relevant fora would be maintained.

As referred to earlier in this report, it was proposed that:

- indicators identified for possible use at national level be tested in a number of countries, to refine the methodology, ascertain the feasibility of data acquisition and confirm the usefulness, or otherwise, of the proposed indicator.
- the optimum formulation of a composite indicator for the security of ex situ collections be further examined by technical experts, and refined, making use of modelling techniques to predict the behaviour of the indicator under various scenarios. The refined indicator could then be tested on a few collections and in a few countries.
- further work would be needed to refine criteria and to design an optimal way of constructing an indicator of the state of diversity of a "basket of crops".

A full proceedings of the workshop would be prepared and made available in due course.

Annex I
LIST OF PRESENTATIONS

Brown, Tony	Indices of genetic diversity and indicators of the status, erosion and deployment of crop genetic resources
Gai, Junyi	A discussion on possible indicators related to genetic structure changes in germplasm conservation
Grum, Mikkel	Genetic diversity, erosion and vulnerability: crop genetic diversity atlas and genetic changes in Mali
Guarino, Luigi	Genetic erosion – some thoughts on its measurements, monitoring and prediction
Guimarães, Elcio	Workshop report on molecular characterization of plant genetic resources for monitoring, conservation and utilization
Mathur, Prem	Measuring and monitoring genetic erosion of pearl millet: landraces through participatory approach – a case study
Parris, Kevin	OECD agri-biodiversity indicators: recent work and future developments
Pham, Jean Louis	Measures and indicators of genetic diversity: with examples from the Philippines and Niger
Ramirez, Marleni	Community-level monitoring of genetic diversity and its social determinants – building on work with Andean farmers
Reeves, James	Genetic diversity and allelic flux in UK cereals
Sangaré, Abdourahamane	Measures and indicators for genetic diversity and erosion in the field – their application in West Africa
Smith, Stephen	Indicators of genetic diversity, genetic erosion and genetic vulnerability and their potential use to monitor diversity in applied plant breeding programs
Subedi, Anil	Indicators of genetic diversity and its social determinants: examples from Nepalese experience

Annex II

LIST OF INDICATORS UNDER CONSIDERATION

Indicator	Relevance / Usefulness	Data availability / feasibility	Level of Application / Aggregation	Notes / Outstanding matters
NUMBER AND SHARE OF SPECIES USED				
1. Number and share of main crops	Provides an overall indicator of between species diversity	Reasonably good data available everywhere at national level, at least for major crops (e.g.: FAO statistics on production and food balance). Would be possible to calculate a Shannon-Weaver or Simpson index, if desired.	Applicable to site (household & community), country and global levels. Available data is by country. For site level could use simple "2 x 2 square analysis"". For aggregation of country data to global level could provide both: • Average # and share of crops by country • Total # and global share.	Whether and how to combine inter-crop and intra-crop diversity. This indicators was proposed by Wetterich, (Fig 8) at OECD workshop.
2. Total number and listings of all species used for food and agriculture, including crop wild relatives	A simple indicator of total species diversity. Provides a checklist for assessing endangered or neglected species.	Much data available, but not all collated.	Applicable to site (household & community), country and global levels.	
3. Total number and listings of endangered neglected and under-utilized species (crops, and harvested wild) e.g.: of 2, number and listing of: Crops covering <[x] ha Neglected by science development (low # accessions; no breeding programme; low #published papers) Species with recalcitrant seeds etc (cannot be easily conserved in seed genebanks) Species classified as threatened or endangered	Informs priorities for conservation and development activities	Sporadic data. Often will have to rely on expert opinion.	Applicable to site (household & community), country and global levels.	

Indicator	Relevance / Usefulness	Data availability / feasibility	Level of Application / Aggregation	Notes / Outstanding matters
NUMBER AND SHARE OF CROP VARIETIES				
5. Total number of crop varieties ("distinct entities") per crop that are available to farmers in the locality/country/world; i.e.: (1) registered varieties; and (2) named varieties / farmer-managed-units of diversity (FMUD)	*Richness of available diversity* Results from type (2) data will be more meaningful for crops for which we have a framework of knowledge about the genetic structure Significance of names varies. (In cases, periodically, might be possible to "calibrate" names against other measures of genetic diversity The balance between (1) and (2) indicates type of systems in country.	Good for registered varieties and for some "heritage varieties" Reasonable for landraces of major crops that have been well-collected (from passport data) Limited for other landraces. (probably would lead to under-estimate of diversity of "informal system")	Applicable to site (household & community), country and global levels, but some problems in aggregation likely due to: (I) double counting because of the same entity been given different names in different places; and (ii) missing data.	Available = what is grown plus what is on the market FMUD= e.g. Named landraces; morhphotypes; races , as for particular crop. Forages, tropical fruits, leafy vegetable etc, and wild relatives may be difficult to treat in this way and require specific treatment The indicator used in the OECD set is "Total number of crop varieties for the main crop categories (*e.g.* wheat, rice) that have been registered and certified for marketing, including native and non–native species and landraces."
6. Share of major varieties in total production for individual crops: either / or: (a) # varieties accounting for [50]% total [acreage][production] (b) % total [acreage][production] of top [5][10] varieties Also, • List names of varieties • % to MVs	*Evenness of diversity in use* *Also relates to vulnerability* To identify potential vulnerability, important to "calibrate" names against other measures of genetic diversity, where possible	Good or reasonable data for most OECD countries and high potential areas in some other countries. (NB. data needed for Shannon-Weaver or other indices would not be available in most countries)	Applicable to site/community, country and global levels. At global level can provide both: average share (weighted and unweighted by country crop areas) and aggregate number.	This indicator is used in the OECD indicator set.
7. Genetic differences among top varieties • Pedigree data; derivatives • Direct measures • As a proxy, see #X	*Distinctiveness* *Also relates to vulnerability*	Availability of pedigree data of commercial varieties may be limited by confidentiality	Applicable to locality, country and global levels. At global level can provide both average difference among top [x] crops, and actual difference among top varieties of named crops	When using direct measures of genetic distance using molecular assays, it is recommended to keep samples of the seed analysed for future analyses with newer techniques

Indicator	Relevance / Usefulness	Data availability / feasibility	Level of Application / Aggregation	Notes / Outstanding matters
ENDANGERED VARIETIES; GENETIC EROSION				
8. Numbers of varieties endangered direct measures: • # and names, where known • indication of population size; area of extent At site level: • varieties in lower right quadrant of 2 x 2 analyses that are not conserved ex situ.	*Relates to erosion* Meaning of "endangered" not clear, different significance in "traditional" and "modernized" systems Particular concern for distinct varieties of particular cultural or livelihood significance Need to distinguish between net loss and turnover (lost genotypes from turnover might be conserved ex situ)	Little comprehensive information available. Generally would have to rely on expert estimate (including extrapolation from field work, GIS, etc).	Applicable to locality, country and global levels, if information available	The indicator used in the OECD set is "Number and share of national crop varieties used in agricultural production that are endangered" Obsolete commercial varieties not considered ""endangered"" if put in secure genebank.
9. Potential genetic erosion (proxy indicators) *Conservation status:* • Landraces / Wild relatives in areas that have not been well-collected *Agricultural Intensification:* • %MVs exceeding [50]%; increase rate of spread of %MVs. • irrigation; increased use of inputs *Structural change* • Rural depopulation; declining %population in agriculture • consolidation of seed/breeding companies; entry of multinational companies in developing countries *Market/demand changes:* • Changing diets; urbanization • Age-distribution; ethnic-distribution • Declining cultivation of minor crops	Provides early warning of possible loss of genetic diversity.	GIS comparisons of collection sites with agro-climatic predictions of crop extent	Applicable to locality, country and global levels, if information available	

Indicator	Relevance / Usefulness	Data availability / feasibility	Level of Application / Aggregation	Notes / Outstanding matters
DYNAMICS OF DIVERSITY ON FARM (TRADITIONAL SYSTEMS); FARMER MANAGEMENT AND TRADITIONAL KNOWLEDGE				
10. Seed system and varietal dynamics: • % new seed, season • Ratio of changed varieties to total varieties per HH / community per [x] years[s] • presence or absence of geneflow with wild relatives	*diversity in time; dynamics of variety release/ farmer system,* Provides indicators of efficiency of variety development system	Data available only in specific cases	Applicable to site, or production system.	Link to (ii); also relevant to traditional production systems (but cannot be compared across types of crop etc).
11. Farmer management and varietal selection; • Degree of specialization of GR-related knowledge and activities, including by gender • Selection, & conservation activities of nodal farmers; farmer-breeders; • measure of network inter-activity; geographical range of influence of the network • Farmer selection criteria (in-field or post harvest); # criteria • Main problems; limitations of existing varieties; likely/planned changes	Provides information on processes involved in the generation and maintenance of diversity on farm.	Data available only in specific cases	Applicable to site, or production system.	
12. Security of traditional knowledge: • Demographics: Age-profile of community; Out-migration • presence or absence of specialist, nodal farmers etc • persistence of local language • availability of local recipes, food processing, festivals etc • legal/institutional frameworks to protect traditional knowledge	Provides information on knowledge that underpins the generation and maintenance of diversity on farm.	Data available only in specific cases	Applicable to site, or production system.	

Indicator	Relevance / Usefulness	Data availability / feasibility	Level of Application / Aggregation	Notes / Outstanding matters
DYNAMICS OF DIVERSITY ON FARM AND IN RESERVE (MODERNIZED SYSTEMS)				
13. Genetic Base • # founder lines • # landraces +crop wild relatives employed per breeding target environment • direct (molecular) measures	Indicates long-run vulnerability of the system. Informs priorities for genetic enhancement and base-broadening	Available often with private companies rarely commercially sensitive	Per production system, per crop	
14. Turnover of varieties • derived from indicator 6			Per production system, per crop	
15. Breeding and genetic enhancement activity • Annual rate of yield increase (running 5 year average) • # independent breeding programmes per crop • # full-time plant breeders • #full- time people / programmes involved in genetic enhancement / population improvement • Size of breeders' working collections; # LR+CWR in breeders' working collections		Some info may be available through international society of breeders..	Per production system, per crop	
ENVIRONMENTAL AMPLITUDE				
16. **Environmental amplitude**	Environmental coverage of variety not always related to diversity			
17. Number of uses of varieties	Does not always correlate to diversity (multiple use varieties)			

Indicator	Relevance / Usefulness	Data availability / feasibility	Level of Application / Aggregation	Notes / Outstanding matters
EX SITU COLLECTIONS				
17. Total number of PGRFA accessions conserved Ex situ	Crude indicator of total diversity. Indicator of collecting effort.	Generally good data on total # accessions,	Collection (by crop and facility); whole facility; country (i.e. national genebank system); global collection (by crop).	The indicator used in the OECD set is "Number of available species and accessions (samples) conserved *in situ* and *ex situ* in national programmes"
18. Total number of crop varieties and wild relatives ("distinct entities") per crop conserved ex situ	Indicator of total diversity, per crop.	less good data on entities.	Collection (by crop and facility); whole facility; country (i.e. national genebank system); global collection (by crop).	
19. Representiveness / coverage of collections for crops by country; crops, globally; or for country	Informs priorities for collecting	Few direct measures of representiveness. Can be estimated using GIS: comparison of collecting sites with crop extent and environmental variation within that extent	Collection (by crop and facility); whole facility; country (i.e. national genebank system); global collection (by crop).	Does it matter if material is conserved in national or foreign/international genebank?
20. Security of each collection (per crop/site combination) • conservation conditions & facility • safety duplication & complement-arity within situ conservation; • regeneration status	Informs collection management decisions	Sporadic data available for each component. Composite indicator could be developed.	Collection (by crop and facility); whole facility; country (i.e. national genebank system); global collection (by crop).	
21. Accessibility and ease of use of the collection • completeness of passport data • characterization data • documentation system	Informs collection management and use decisions	Sporadic data available for each component. Composite indicator could be developed.	Collection (by crop and facility); whole facility; country (i.e. national genebank system); global collection (by crop).	
22. Availability – legal issues: • Whether or not in Multilateral system and/or international network, and/or otherwise freely available	Informs collection management and use decisions	Data will be available once IT enters into force	Collection (by crop and facility); whole facility; country (i.e. national genebank system); global collection (by crop).	
