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Compilation of Submissions Received from Contracting Parties, Non-Contrating Parties and International Relevant Organizations

Input Paper from Bioversity International, CIAT, CIP and GBIF: Global Information System for In situ Conservation and On-farm Management of PGRFA

Global Information System for *In situ* Conservation and On-farm Management of Plant Genetic Resources for Food and Agriculture

Input Paper

For the ITPGRFA Consultation on the Global Information System on Plant Genetic Resources for Food and Agriculture (COGIS-PGRFA)

21 July 2014

"I am convinced that the lack of adequate biodiversity monitoring is at the heart of our difficulties to make convincing arguments. A Government that sees what its policies do to biodiversity because it has access to reliable data will be less likely to risk biodiversity loss and more likely to find solutions that embrace biodiversity as a part of such solutions."

Braulio Dias, Executive Secretary, Convention on Biological Diversity (CBD)
message to the Global Biodiversity Informatics Conference, 2012

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The Platform on Agrobiodiversity (PAR), Agropolis International and UN Organization for Food and Agriculture (FAO) expressed their support to the vision of such a global information system for *in situ*/on-farm conservation.

List of acronyms used

AgTrials: Global Repository of Evaluation Trials of Climate Change For Food and Agriculture
CBD: Convention on Biological Diversity
CBO: Community-Based Organization
CBR: Community Biodiversity Register
CIRAD: Centre International de Recherche Agronomique pour le Développement
CGIAR: Consultative Group on International Agricultural Research
CGRFA: Commission on Genetic Resources for Food and Agriculture
CIAT: Centro Internacional de Agricultura Tropical
CWR: Crop Wild Relatives
DFID: Department for International Development
FAO: Food and Agriculture Organisation of the United Nations
GBIF: Global Biodiversity Information Facility
GCDT: Global Crop Diversity Trust
GEO BON: Group on Earth Observations Biodiversity Observation Network
GIS: Geographic Information System
GPA: Global Plan of Action
GRIN: Germplasm Resources Information Network
IADB: Inter-American Development Bank
ICT4Ag: Information Communication Technology for Agriculture
ICT4D: Information Communication Technology for Development
ILTER: International Long-Term Ecological Research network
IRD: Institut de Recherche pour le Développement
ITPGRFA: International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN: International Union for Conservation of Nature
IWMI: International Water Management Institute
LOD: Linked Open Data
LR: Landrace
MEA: Millennium Ecosystem Assessment
NARI: National Agricultural Research Institute
NBSAPs: National Biodiversity Strategies and Action Plans
NUS: Neglected and Underutilized Species
NGO: Nongovernmental Organization
PACS: Payment for Agrobiodiversity Conservation Services
PGRFA: Plant Genetic Resources for Food and Agriculture
SDM: Species Distribution Modelling
SoW PGR: State of the World's Plant Genetic Resources
SoW BFA: State of the World's Biodiversity for Food and Agriculture
SRLI: Sampled Red List Index
TK: Traditional Knowledge
UN: United Nations
UNEP-WCMC: United Nations Environment Programs-World Conservation Monitoring Center
UNU-IAS: United Nations University – Institute for Advanced study on Sustainability
USAID: United States Agency for International Development
USDA: United States Department of Agriculture

Content

I. Summary

A case for developing collaboratively a global information system or systems for *in situ* conservation and on-farm management[1] of PGRFA, as complementary to existing ex situ information systems, is presented, as a contribution to the implementation of Article 17 of the International Treaty on Plant Genetic Resources for Food and Agriculture. The key objectives of such an information system for *in situ* conservation and on-farm management are to provide information about PGRFA located *in situ* and on farm to meet the needs of target users (custodian farmers, research organizations, NGOs, national authorities, international organizations, global treaties and conventions) and to monitor changes in this diversity, both of which will help and support decision-making processes by different target users. The challenges, functions, principles and expected outcomes in establishing such an information system are discussed, as well as the needs of target users. Given the complexity of *in situ* conservation and on-farm management, it is recognized that an information system will need to handle data from various sources and may have to be organized in a number of different databases. To capture all the data identified by user groups, the global information system should combine nomenclature and biophysical data, ecogeographical information, seed exchange systems, socio-economic data, associated traditional knowledge, policies, seeds laws and regulations. Data analysis needs to be performed at various scales, from gene to landscape, and over time. Interoperability of the data is required combining the collective knowledge from farmers, citizen scientists and researchers. The system needs to support frequent interactions between communities, stimulating exchange of knowledge between farmers, and between farmers and scientists, through a multifunctional information facility integrating technologies from citizen science and social network systems and providing appropriate datasets on demand. This input paper also provides a brief overview of some existing initiatives which would be important collaborators and data contributors for a global information system for *in situ* conservation and on-farm management.

II. Introduction

Article 17 of the International Treaty on Plant Genetic Resources for Food and Agriculture (henceforth called the Treaty) calls for the development and strengthening of a global information system for Plant Genetic Resources for Food and Agriculture (PGRFA). To facilitate access to PGRFA, it is critical that information about the diversity found on farm, *in situ* and *ex situ* is well documented. While progress has been made in documenting PGRFA held by the major genebanks around the world, through global, regional and national databases (e.g. Genesys, EURISCO, GRIN and national documentation systems), the state of knowledge on agrobiodiversity found on farm and in the wild has not been addressed and remains very limited. Global information is available at species level[2] but not at the intra-specific level and to date there is no global initiative to address this informational limitation. Other articles from the Treaty explicitly relate to the promotion of *in situ* conservation and on-farm management (Article 5) and protection of traditional knowledge on PGRFA (Article 9).

In this input paper, we make a case for collaboratively developing a global information system for *in situ* conservation and on-farm management of PGRFA, which will also serve as a monitoring system for genetic diversity changes *in situ* and on farm, as a contribution to the implementation of Article 17 of the Treaty. Such a collaborative approach is proposed because there is a need for coordination and cooperation within and among countries in addressing the specific challenges they share in documenting the national and regional status of *in situ* and on-farm PGRFA in order to make appropriate decisions regarding their conservation. A global information system on *in situ* conservation and on-farm management should be able to provide an overview on the global status of

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[1] In this paper, we refer to '*in situ* conservation' as the conservation of wild species of importance to agriculture (such as crop wild relatives) in wild habitats (unmanaged by humans) and 'on-farm management' as the maintenance of local varieties or landraces in farmers' cultivated fields.

[2] e.g. Data portal of GBIF, Red List of IUCN, Global Invasive Species Database, species pages of Encyclopedia Of Life, UNEP-WCMC, FAO statistics , etc.

PGRFA conservation, support the monitoring of Treaty implementation and provide governments with information to support their decision-making processes about *in situ* and on-farm conservation strategies. In addition, the information system should provide information services useful to farmers and other actors involved in the conservation and use of PGRFA. Solid baseline data and operative long-term monitoring systems, based on scientifically sound indicators and metrics, are prerequisites for the generation of evidence about whether landrace replacement or displacement, crop wild relative species extinction, and genetic erosion or enrichment are actually occurring in diversity hotspots and elsewhere. A key function of the information system could be to identify where such major change is occurring, so that interventions may be taken to safeguard PGRFA and help ensure that such changes in diversity are positively affecting farmers' livelihoods and health. For example, where there are threats to diversity, strategies for collecting threatened varieties and species for *ex situ* conservation or for investing in *in situ* conservation or on-farm management can be developed and implemented. The in situ/on farm information system should be seen as complementary to existing global ex situ information system Genesys and appropriate links between them created.

The functions of the global information systems on *in situ* conservation and on-farm management could be summarized as follows:

- To support local use and conservation of PGRFA, crop wild relatives and landraces
- To monitor the status and trends of PGRFA *in situ* and on farm
- To facilitate seed exchange mechanisms that promote the use of farmers' preferred seeds
- To better understand the impact of agricultural development policies on PGRFA
- To better understand the relationship between PGRFA, agroecosystem resilience and human health
- To provide decision makers with information that will help design policies supporting conservation and use of PGRFA.

Expected outcomes that may be derived from the use of the information system and be useful to a wide range of target users would be likely to include the following:

- Improved understanding of the status and trends of PGRFA, as well as associated drivers and the impact of PGRFA management on agroecosystem health
- Identification of areas with potential gene flow between crops and wild relatives. For example areas with high richness overlapping with conservation areas (national parks, reserves)
- Improved models for climate change scenario analysis and assessment of potential adaptation capacities of crop wild relatives, varieties and landraces to predicted climate change in specific locations
- Understanding crop domestication patterns and evolutionary genetic processes (including historical evolution) that influence the current and future distribution of PGRFA diversity
- Enabling predictive characterization of PGRFA to support strategies for seed dissemination and participative evaluation of varieties and landraces to target community, environments and agroecosystems
- Improved variety selection and interventions related to agroecological intensification, conservation agriculture and ecosystem service maintenance
- Improved understanding of the social and cultural factors impacting the on-farm distribution and management of PGRFA diversity and access to quality seeds
- Availability of gender-disaggregated information on: farmer preferences, management practices, use and livelihood improvement opportunities

The information system would provide a useful mechanism through which to aggregate country-level information to inform regional and global initiatives. The main global institutions expressing a demand for this kind of information are: the Treaty, in the context of the implementation of Article 17; the Convention on Biodiversity (CBD), with a view to monitoring progress towards the Aichi targets (Target 13); the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) in order to monitor progress on the implementation of the Global Plan of Action for PGRFA (GPA); Global Crop Diversity Trust (GCDT) for building linkages with existing global ex situ information system (Genesys); IUCN in the context of monitoring the extinction risks of wild species; and the Global Biodiversity Information Facility (GBIF) with the aim of providing improved coverage of biodiversity information. At national and local levels, there is a suite of different organizations, which would benefit both from the existence of the improved national information that such a global system would be built upon, and also from the existence of regional and global comparative data and analysis (e.g. regarding best practices). Such organizations include national agencies (ministries, national agricultural research institutes), local governments, nongovernmental organizations, local community-based organizations and farmer cooperatives. In addition, development agencies (DFID, USAID, CIRAD, IRD, etc.) and the development banks (World Bank, IADB, etc.) would find this information useful.

III. Global information systems on in situ/on farm PGRFA: challenges and needs

Creating a global information system for *in situ* conservation and on-farm management of PGRFA is likely to be much more difficult and complex than dealing with *ex situ* data. A number of key challenges can be identified, including:

- The **scope** of any global information system would need to be clearly defined. PGRFA in the Treaty context relates to all crops and their wild relatives. It is recognized that crop wild relatives (CWR) and on-farm diversity (e.g. varieties, landraces etc.) require different conservation approaches involving different stakeholders. Expertise needed, data types to identify and prioritize, metadata, visualization and analysis tools will not be fully similar for both. They may require different information systems that would target the diversity in CWR and landraces or local varieties. For example, significant work has already been carried out related to the measuring and monitoring of wild species. Species distribution models can estimate climate suitable areas of wild species and their potential distribution; tools and standards are globally accepted; crowdsourcing of species occurrences, peer-review of data and close collaboration with plant taxonomists are already widely applied for wild diversity. Online checklists of wild species names already exist, which facilitate the identification of CWR. These do not exist for landraces, so inventorying landraces will bring new challenges, such as dealing with local names and their variation. Options for creating a **single information system or two separate information systems** for *in situ* conservation and on-farm management respectively should consequently be examined. Given the nature of *in situ* conservation and on-farm management and the sources of information of the two, it may be argued that a preferred option might well be to have two separate information systems, with a view to increasing clarity and enabling stakeholder contributions. However in the remaining part of this paper we continue to refer to one global information system for simplicity's sake, while recognizing that there may be two different information systems for CWR/wild species and on-farm diversity.
- The information system should **take into account the many drivers** which influence diversity on farm and *in situ*. The Millennium Ecosystem Assessment (MEA 2005) identified five major drivers of biodiversity loss: climate change, habitat change, invasive alien species, overexploitation and pollution. Of these, the first three arguably pose the greatest threat to PGRFA with, in addition, in many countries, the unintended effects of increased agricultural intensification and the introduction of new varieties also being significant factors in the loss of traditional crop diversity (FAO, 2010). Other important socio-economic factors also play a role,

including farmers' access to seeds and markets, as well as underlying institutional and policy environments.

- **Structure of the global system:** Effective strategies and systems to capture, store, index, analyse, integrate, disseminate and interpret available information and knowledge, both traditional and new about PGRFA are a critical prerequisite for a functioning global information system. Unfortunately, effective access to information about PGRFA is not yet feasible on a global scale, impeding the sharing of knowledge and associated PGRFA materials. Compiling an inventory and complete information about all available *ex situ* and *in situ*/on-farm managed PGRFA, in a global online system, is a major research and development challenge which will require a very broad global collaboration of data providers, institutions and stakeholders. **Existing information** on *in situ* and on-farm PGRFA is much more scattered than *ex situ* information, and it is poorly described and organized.

  The system would consequently be expected to provide an entry point to a large range of datasets (Table 3). A **distributed information system** on crop diversity and associated practices at the scales where this diversity thrives and is effectively managed may be considered. Such a distributed system would be able to make use of the recent progress in knowledge management technologies, participatory processes and agile informatics[3] development to develop online information services, using appropriate thesauri and ontologies. Through the use of an open, flexible, user-driven infrastructure, the knowledge and know-how produced at various scales (from global to local), by different actors (scientists and knowledge users), and on different crop status (from neglected or underutilized species to major crops) could be structured and integrated.

  The information services provided by such a system would need to be **designed for the technical capacities of specific target audiences**, so as to facilitate their access and contribution to the information. In order to reach the largest possible number of end users, the system may consider including technologies promoted by Information Communication Technology for Development and Agriculture (ICT4D, ICTAg), which promote the use of mobile devices alongside communication media like radio broadcasting, fairs, factsheets and face-to-face consultation.

- There is a need to ensure **fair sharing of data and knowledge**, avoiding any charges of misappropriation of Traditional Knowledge (TK). Protocols governing access to the databases and information tools should need to be clearly stated and agreed with the TK holders and users, for example in accordance with the recommendations of a report from UNU-IAS (Bhaati, Hardison and Neumann 2003), including correct and agreed citation of the community and individuals.

IV. Users and requirements

Target audiences and needs

A global information system would not be expected to provide a single access solution for all users but to use the formats and media that are most frequently adopted by the target users. Table 1 summarizes the target user communities, the role they can play in such a system and the information they are expected to need to access.

Table 1: Target users of a global information system on *in situ* conservation and examples of their role and information needs

Target audience	Role in PGRFA conservation and use	Products and services needed by target audience
Custodian farmers[4]	• Facilitate the maintenance of the	• Information regarding the agronomic traits of wild species and

[3] It is a conceptual framework that promotes adaptive planning, active user involvement, iterative approach, and encourages rapid and flexible response to change.

[4] Custodian farmers are those who actively maintain, adapt and disseminate agricultural biodiversity and related knowledge, over time and space, at farm and community levels and are recognized by community members for it. Often, custodian farmers are actively supported in their efforts by family or

Target audience	Role in PGRFA conservation and use	Products and services needed by target audience
	evolutionary dynamics of diversity • Conserve and distribute seeds to other farmers, along with the preferred traits and knowledge on cultivation and processing • Participatory selection of varieties/landraces/species • Maintain community seedbanks and participate in other exchange mechanisms • Contribute to the collection of monitoring data on PGRGFA diversity on farm, climate (e.g. rainfall), soil quality, disease challenge, etc. • Participate in value chain development activities	landraces with agronomic traits in an accessible format • Accessibility of quality seed of preferred varieties • Knowledge regarding best conservation and use practices • Knowledge regarding potential nutritional, feed and income generation values • Climate and agronomic information
National and international research institutes, breeding programmes, universities,	• Develop technologies for the conservation and enhanced use of PGRFA • Facilitate participatory selection of on-farm diversity • Assess the conservation status and trends of the PGRFA using standardized methods, tools, and databases • Support indicator development, monitoring system, data analysis and dissemination of findings • Inventory, describe and analyse PGRFA and its role in socio-ecological systems	• Catalogues of landraces and wild species • Information regarding the distribution of species/varieties, genotype x environment interactions, traits, etc. • Information regarding quality seed availability and PGRFA conservation and use practices • Red List and landrace inventories • Methodologies, guidelines , tools and best practice guidelines • Farmer trait preferences
NGOs (national and international)	• Farmer training in seed maintenance and multiplication • Community Biodiversity Register [5] promotion and support • Monitoring, including with regard to access and benefit sharing • PGRFA conservation and use policy advocacy (including with regard to farmers' rights and gender issues) • Support for value chain development activities • Dissemination of information to farmers (radio broadcasting, fairs)	• Agronomic and plant trait data, production system characteristics and practices • Inventory of CWR and landraces, • Nutritional values • Information on community seedbanks, seed exchange networks and regulations
Policymakers, local authorities, ministries , regional and local authorities	• Develop and implement PGRFA-related policies, including related to conservation strategies and seed systems • National-level monitoring, including with regard to access and benefit sharing	• Evidence base of ecosystem services provided by PGRFA • Evidence base of the impact of policies and development projects on PGRFA • Map of PGRFA at various scales and granularity • Indicators and decision-making models • National Biodiversity Strategy and Action Plan • Country report

household members. (Workshop on Custodian Farmers of Agricultural Biodiversity: Policy support for their roles in use and conservation (New Delhi, 11–12 February 2013)

[5] A Community Biodiversity Register (CBR) is the documentation of the resources and knowledge of biological resources of communities at the local, regional and national levels, by the people themselves for the purpose of rejuvenating the knowledge and conserving biodiversity. The CBR is a tool keeping biodiversity knowledge alive in the community. The CBR can also be seen as a political tool to empower people and bring awareness (Green Foundation)

Target audience	Role in PGRFA conservation and use	Products and services needed by target audience
International bodies (ITPGRFA, CBD-Aichi, CGRFA, FAO GPA, IUCN, GBIF, Trust)	• Global-level monitoring • Access and benefit sharing • Early warning • Develop international policies, guidelines and global plans of action (including with regard to farmers' rights and gender issues)	• Country inventories • Indicators on status and trends of PGRFA • State of the World reports

User engagement and partnership

The development of a distributed global information system would be likely to benefit from adopting participatory approaches and being based on local and national level information (Jarvis et al 2011). Local and national stakeholder representatives need to be involved in preliminary discussions about the design of the system and priority setting of the information services for short-term and long-term objectives. These representatives could then ensure well-designed interventions with communities while gaining insights into the conditions for successful exchange of complex agrobiodiversity information. Frequent interactions would be necessary throughout the implementation process with stakeholder communities acting simultaneously both as users and producers of data, information and knowledge. Such an approach would also support and strengthen knowledge and experience sharing within and between communities, favouring a multi-actor approach to management of agrobiodiversity.

Participatory mechanisms for gathering diversity data on farm and *in situ* should be considered and would require the involvement of a range of stakeholder groups including women and men farmers, research institutions, local governments, community-based organizations, nongovernmental organizations and other conservation practitioners. In order to get a representative view of the status of PGRFA globally, it may be necessary to consider a global network of monitoring sites, as recommended by the Commission on Genetic Resources for Food and Agriculture (CGRFA 13, FAO 2011).

Stakeholder groups who are permanently present in the monitoring sites offer opportunities for enhancing project sustainability, supporting institutions of collective action and maintaining traditional knowledge. For example, farmers and community-based organizations could regularly provide information to community biodiversity registers and participate in associated verification mechanisms, as they already do in some countries such as Nepal and India. Emerging payment for agrobiodiversity conservation services (PACS) schemes (Krishna et al 2013, Narloch et al. 2013) could be used to determine and cost the type of support, inputs, and incentives that might be needed to facilitate the active engagement of communities in providing a PGRFA conservation monitoring service.

Corroboration of existing diversity information and that sourced through a participatory monitoring system and any associated CBRs constitute an important element in ensuring reliability of the data and findings. Other means of verifying the reliability of data should also be considered. Surveys could be carried out in diversity hot spot areas and relevant crop diversity indexes used to reconfirm landrace diversity documented previously as well as the main agro-morphological traits associated with each landrace. Following such verification, integration of the validated genetic diversity data into national agrobiodiversity programme monitoring systems (and feedback to communities) could take place. The establishment of a system of CBRs forms a key element in this process, with CBRs expected to report back periodically (e.g. around planting and harvest times) by whatever means is most appropriate (electronic or otherwise) to a central registry housed at the competent national partner institution. At a country level, information (even if incomplete and variable) could be obtained through reports countries already prepare for initiatives like State of the World of PGRFA, State of the World's Biodiversity for Food and Agriculture (SoWBFA) and National Biodiversity Strategies and Action Plans (NBSAPS). These are existing initiatives from which relevant information can be obtained. In this context, the information requested from countries for SoWBFA may be relevant (see CGRFA website). The challenge of country-based provision of information might be one of the main issues for further debate as part of a discussion on sources of information.

Gender issues: Often women's needs and knowledge are left out of agricultural development initiatives and so it is important to ensure that this does not happen in this system. At the community level and in the context of work associated with monitoring, gender dimensions should be considered by: i) adopting methodologies which ensure that both women and men are represented and that their voices are heard; and ii) undertaking research which leads to an improved understanding of the differentiated roles and responsibilities of women and men, as well as of broader social groups, in the maintenance (including monitoring) of PGRFA and with regard to related access and benefit sharing. Such an approach is expected to lead to the design of more efficient, relevant and socially equitable monitoring interventions.

Partnerships: Synergies of actions between the Treaty, GBIF, CGIAR, FAO, GCDT, Agropolis and other partners acting in similar domains (see section VI) can be identified for building capacities in target countries. Biologists from GBIF participating countries already reporting vegetation occurrence data to the GBIF portal and International Long Term Ecological Research (ILTER) could receive training and support to include CWR *in situ* populations in ongoing vegetation monitoring activities. Furthermore, the GBIF network of participant country node staff could be mobilized to identify and contact new CWR data sources and to assist with the technical infrastructure and skills to mobilize CWR *in situ* data. Such tasks are already part of their mandate and daily operations. Mobilization of data on on-farm diversity could potentially also use the network of national and regional GBIF nodes with a solid collaboration of experts in agrobiodiversity.

Governance: Some kind of governance mechanism will be required for the information system. This will need to be discussed and agreed among the stakeholders through a participatory approach, so that their views, and feedback can be taken into account.

V. Design and content of the global information system

A global information system should be capable of providing aggregated and integrated open access data on *in situ* conservation and on-farm management to a range of stakeholders. The existence of a comprehensive, reliable and publically accessible PGRFA information system would be expected to contribute to improved PGRFA-related decision-making processes at various scales. In such a context, consideration of what information is likely to be critical to informing such decisions is important.

A global information system for *in situ* conservation and on-farm management could be designed with the following desirable characteristics:

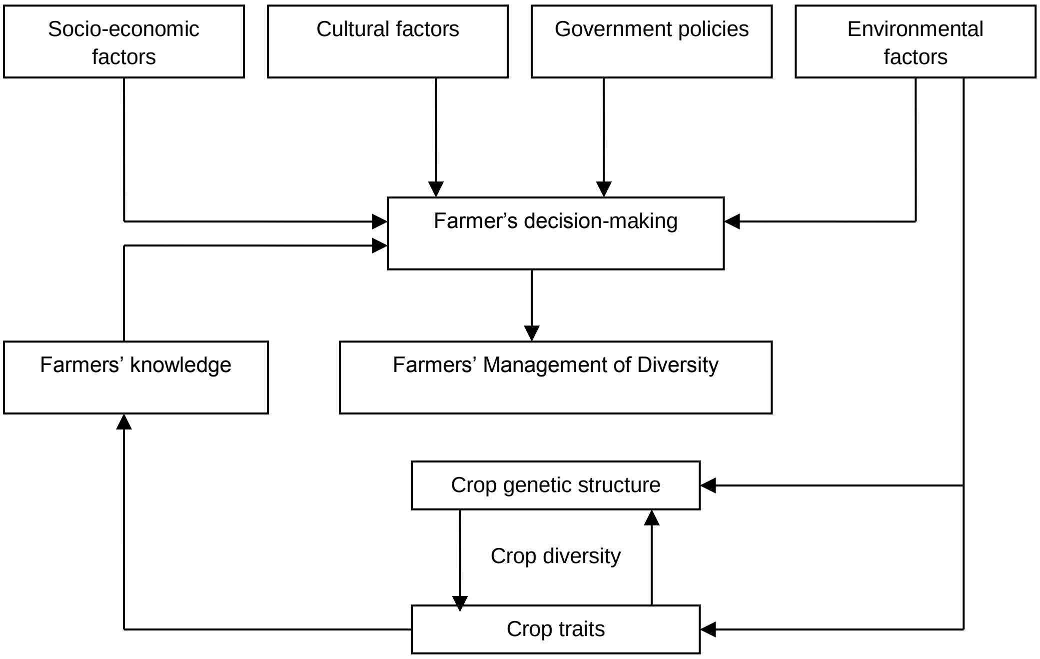
- Potential to combine country-level information on PGRFA in order to obtain a global overview of status and trends
- Capacity to address information needs on landraces in cultivated areas and CWR in natural areas, including of species important to local communities and,
- Providing the means with which to analyse and understand the dynamics of PGRFA diversity at various scales and facilitate conservation strategy development
- Facilitating the accessibility of information services in an appropriate format for a wide range of stakeholders.

A first step in the design of a global information system (or systems) with such characteristics would be to determine what information is likely to be critical to supporting the decision making of its target users. In addition to identifying what type of data need to be collected, where such data are found and who would provide these data, it would also be necessary to clearly define key indicators and metrics related to each of the products and services mentioned above. In this context, we note that there is a large body of work on indicators for the conservation and use of PGRFA both at genetic, species and landscape levels (Brubaker and Brown 2002, Brown 2008, Jarvis et al 2008, Pereira et al 2013, Nguyen and Drucker 2013, CIP 2013 etc.) that can be drawn upon.

Mobilizing key information

In order to address the complexities of *in situ* conservation and on-farm management, involving a matrix of interrelationships between scientific, socio-economic, technological, agricultural and resource management, a systematic organization of the data in a manner that is sufficiently generic, yet supporting internal structuredness and maintaining standards is needed (Jarvis et.al. 2003). Some conceptual frameworks on how to organize data for on-farm diversity are available (Figure 1) (Smale and Bellon 1999, Bellon 1997, Jarvis et al. 2011 and can be a good starting point for designing the information system.

Figure 1. Conceptual model of the factors that influence farmers' management of diversity. Source: Bellon *et al.* (1997)



Given the nature of on-farm management, it is likely that the information will have to be organized in a number of different databases, as argued by Jarvis et al. 2003). Nonetheless, some of the key data types for *in situ* and on farm information system(s) are likely to include the following (See Table 2 for summary):

Diversity of crop wild relatives and landraces *in situ* and on farm

This is the basic information that an *in situ* conservation and on-farm management information on PGRFA should provide. It is about providing knowledge regarding what diversity exists and where, who owns it and how levels change over time. It should include taxonomic/nomenclature information as well as diversity at the phenotypic and genetic level and trait information. Although a great deal of this type of information is already available, datasets are not linked to each other and so their potential for informing evidence-based decision making is reduced. Furthermore, not all this information is adequately documented; in particular, many species that are less researched are inadequately documented, but are often of importance for farmers' well-being. Facilitating the discovery of data stored from various sources, using formal format, unstructured records and multimedia would be useful in this context.

Ecogeographic information

An *in situ* conservation and on-farm management information system would need to contain basic eco-geographic information (climate variables, water availability, soil type, vegetation type, land cover, latitude, longitude, altitude, spatial distribution of pests and diseases, etc.). This information is critical to allow users of the information system to locate traits of interest (e.g. drought, disease or salinity tolerance) and also to identify sites with similar conditions where the varieties or species could perform well. Participatory Variety Selection[6] projects would particularly benefit from the availability of such information. Predictive characterization projects for identifying promising germplasm could support such work through the use of tools such as Focused Identification of Germplasm Strategy (FIGS) (Mackay and Street 2004, Street et al. 2008) developed by the International Center for Agricultural Research in Dry Areas (ICARDA) or the ecogeographical filtering method (Parra-Quijano et al. 2012a, b) which combines spatial distribution information regarding the target species with ecogeographical identification of the environments that are likely to impose selection pressure for a selected trait. Edaphic, geophysic and bioclimatic variables most relevant for adaptation can be identified and used together with ecogeographic land characterization maps to identify promising occurrences (Thormann et al. 2014)

Seed exchange systems (formal and informal including community seedbanks)

Seed exchange systems are an important, yet poorly understood, factor shaping crop diversity and its dynamic use on farm. Thus knowledge about the type and characteristics of the seed systems underpinning access to PGRFA diversity and its geographical distribution in the field should be described for each site in the information system. Particular attention might be paid to community-based seed-banking initiatives, which have emerged in different contexts around the world as a participatory mechanism to strengthen local seed and food security practices, counter the loss of agricultural biodiversity on farm and cope with environmental stresses and climate change related challenges (Vernooy 2013).

Socio-economic information

Information regarding production system, market and household characteristics, disaggregated by gender, would also be important for understanding local on-farm management practices and preferences.

Associated traditional knowledge

Under Article 9, the International Treaty recognizes the enormous contribution that local and indigenous communities and farmers of all regions of the world, particularly those in the centres of origin and of crop diversity, have made and continue to make with regard to the conservation and development of PGRFA. Governments are responsible for implementing Farmers' Rights, including those related to safeguarding traditional knowledge relevant to PGRFA, in particular: the right to equitably participate in the sharing of the benefits arising from the use of plant genetic resources; and the right to participate in making decisions, at a national level, on matters related to their conservation and sustainable use. There is thus a need for such traditional knowledge to be documented/captured by the information system.

Policies, seed laws and regulations

Policies, or the absence of them, affect how national governments, research organizations, conservation organizations, companies and farmers manage and conserve crop diversity. Therefore, it is crucial to develop a common knowledge of seed exchange policies and regulations and status of land use for the on-farm and *in situ* sites. Policies and institutions influence the willingness of actors to share crop diversity with one another. By influencing management decisions at various scales, policies affect how crops evolve, and the extent to which the ecosystem services that crop diversity

[6] It is also a selection process of testing released or promising genotypes in farmers' fields. PVS includes research and extension methods to deploy genetic materials as an on-farm experiment. Therefore, the variety developed through PVS can meet the demands of different stakeholders.

provides benefit farmers and other actors. Research results shared through a global information system can be used for three areas of policy work: (1) increasing understanding of how different actors actually use crop diversity, and the incentives they have for continuing those practices, (2) developing and testing policy options to enhance these actors' ability to take advantage of crop diversity in pursuit of food security and ecosystem health, and (3) strengthening the linkages between policy actors and enhancing their collective capacity to conduct policy research and make contributions to policy development processes. The ultimate aim is to create an enabling policy environment for the conservation, exchange and use of crop diversity from local to global levels of activities, as part of strategies to achieve food security and enhance ecosystem services.

Table 2. Summary of key information and relevance to *in situ* conservation of wild species and on-farm management

Key information	***In situ* conservation of wild species**	**On-farm management of local crop diversity**
Distribution		
Nomenclature data	Taxonomy and vernacular names	Taxonomy and checklists of traditional names in relevant languages
Occurrence and abundance	Natural distribution and populations	Geospatial distribution information in cultivated areas
Plant characteristics and performance		
Phenotypic and trait data	Morpho-taxonomy, adaptive traits, functional traits	Morpho-taxonomy, agronomic traits (farmers and breeders), functional traits
Genetic data	Genepool, degree of genetic relativeness	Identification, pedigree
Environment		
Eco-geographic information	Climate variables, water availability, soil type, vegetation type, land cover, latitude, longitude, altitude, phenology, spatial distribution of pests and diseases etc.	Climate variables, water availability, soil type, vegetation type, land cover, latitude, longitude, altitude, spatial distribution of pests and diseases, cropping systems
Socio-economic information	Demography, protected areas, industry expansion (mining, eic.)	Production system, market and household characteristics, field management, types of seed system
Associated traditional knowledge	Uses, locations of specimens	Uses, agronomic practices, cultural practices, seed conservation and exchange
Policy, seed laws and regulations	Policy, seed laws and regulations on wild diversity	Policy, seed laws and regulations on domesticated plants, seed exchange, markets

VI. Relevant Existing Information Initiatives

Effective strategies and systems to capture, store, index, analyse, integrate, disseminate and interpret available information and knowledge, both traditional and new, about PGRFA is a critical prerequisite to a functioning global system of sustainable conservation, management and use. An efficient approach for a global information system would be to build upon and reuse resources from existing infrastructures and databases. Developing ways to make these data sources interoperable would help end users to access the wealth of already existing information in a meaningful way for their own objectives, without duplication of efforts. Such an approach would also help to identify any gaps in information coverage, the quality and fitness for use of the published data and enable peer review of the data.

Some of the existing initiatives, which would be important collaborators and data contributors for a global information system for *in situ* conservation and on-farm management, are summarized below (Table 3). Existing experiences related to global information gathering (and information systems) for animal (livestock), forestry and aquatic genetic resources, which involve very substantial *in situ* and genetic resource dimensions, may provide useful examples and lessons for the design of a PGRFA global information system.

Table 3: Non-exhaustive list of major public sources of data and information that would be valuable contributors to such a global system

Taxonomy	
	GRIN-USDA
	Mansfeld's World Database of Agriculture and Horticultural Crops
	Checklist of crop wild relatives from the Crop Wild Relatives project
	Catalogue of Life, International Plant Name Index
	Encyclopedia of Life
Genetics	
	Genebank data
Diversity occurrence and abundance	
	Global Biodiversity Information Facility (GBIF)
	International Long-Term Ecological Research Network (ILTER)
	Crop Wild Relative Database of the CWR project
	Collecting missions geodatabase
	Atlas of Hotspots of Agrobiodiversity
Inventories	
	Crop Wild Relative Portal
	Genesys
	Plantdatabase USDA
	FAO WIEWS
	State of the world reports on PGRFA
	Global Database for Invasive Species
Plant traits and uses	
	Global Repository of Evaluation Trials of Climate Change For Food and Agriculture (AgTrials)
	TRY, Plant Trait Database
	Agroforestry database (ICRAF)
	Trait database of Encyclopedia of Life
	Collecting missions geodatabase
	PlantUseDB, Seed Information Database, Kew Botanical Garden
Environmental data layers	
	Soils and land cover: e.g. Atlas of African Soils (Afsys)
	Climate: e.g. aWhere, Worldclim
	Water: IWMI
	CCAFS GCM Climate data portal
	CliMond global climatologies for bioclimatic modelling
	Geonetwork
Metric and indicators	
	FAO Indicators for monitoring implementation of second GPA
	CBD for Aichi targets
	IUCN Red List of Threatened Species ™
	Indicators for conservation and ecosystem services
	Indicators for resilience of Social ecological production landscape
	Indicators for Genetic Diversity, Genetic Erosion and Genetic Vulnerability for PGRFA
	Agrobiodiversity indicators
Statistics/EconomIcs	
	FAOStat
	Worldbank database

Bibliography	
	AGRIS 2.0
	CABI

Global Biodiversity Information Facility (GBIF)

GBIF is an international open data infrastructure, funded by governments, encouraging and helping institutions to publish data according to common standards. Many GBIF participant countries have set up national portals using tools, codes and data freely available through GBIF to better inform their citizens and policymakers about their own biodiversity. GBIF operates through a network of nodes, coordinating the biodiversity information facilities of participant countries and organizations, collaborating to share skills, experiences and technical capacity. It provides a single point of access to more than 400 million records, shared freely by hundreds of institutions worldwide, making it the biggest biodiversity database on the Internet. The data accessible through GBIF relate to evidence about more than one million species, collected over three centuries of natural history exploration and including current observations from citizen scientists, researchers and automated monitoring programmes. More than 900 peer-reviewed research publications have cited GBIF as a source of data, in studies spanning the impacts of climate change, the spread of pests and diseases, priority areas for conservation and food security. Under an agreement with the Secretariat of the Convention on Biological Diversity (SCBD), the GBIF Secretariat has up to now been the primary focal point of the Global Invasive Alien Species Information Partnership (GIASIP), which brings together a number of organizations focussed on improving the interoperability of different information sources on this major driver of biodiversity loss. GBIF provides both the information infrastructure and a communication platform where networks such as the GIASIP (and perhaps a new global information system for PGRFA) can be formed.

International Long-Term Ecological Research network (ILTER)

ILTER is a 'network of networks', a global network of research sites located in a wide array of ecosystems, which can help understand environmental change across the globe. ILTER's focus is on long-term, site-based research and monitoring. ILTER can contribute to solving international ecological and socio-economic problems through question- and problem-driven research, with a unique ability to design collaborative, site-based projects, compare data from a global network of sites and detect global trends. Most ILTER members are national or regional networks of scientists engaged in long-term, site-based ecological and socio-economic research (known as LTER or LTSER). They have expertise in the collection, management and analysis of long-term environmental data. Together they are responsible for creating and maintaining a large number of unique long-term datasets.

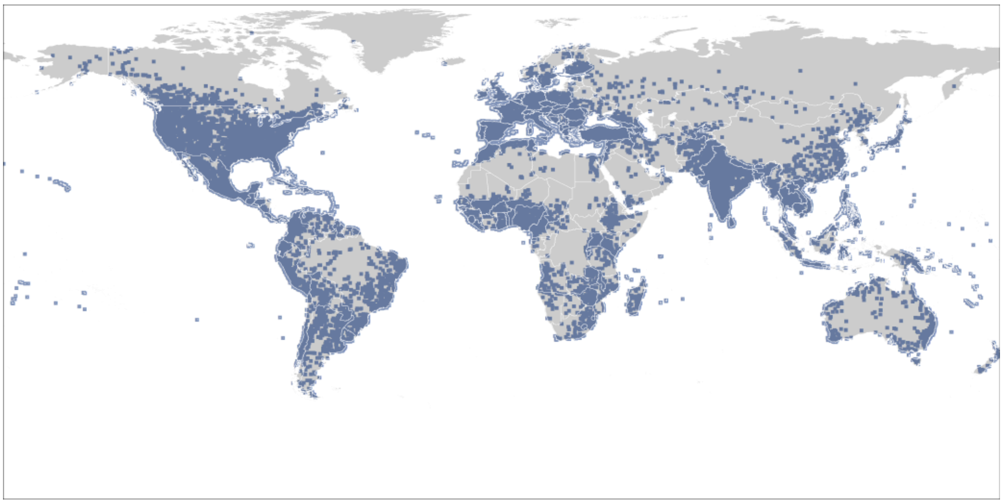
The Global Invasive Species Database (GISD)

GISD aims to increase public awareness about invasive species and to facilitate effective prevention and management activities by disseminating specialist knowledge and experience to a broad global audience. The GISD was developed as part of the global initiative on invasive species led by the Global Invasive Species Programme (GISP) and is managed by the Invasive Species Specialist Group (ISSG) of the Species Survival Commission of the IUCN. The Global Invasive Species Database is a free, online, searchable source of information about species that negatively impact biodiversity. It focuses on invasive alien species that threaten native biodiversity and covers all taxonomic groups from micro-organisms to animals and plants.

Crop wild relative database and checklist from the crop wild relative project

A global taxonomic and geographic occurrence dataset for crops and their wild relatives was compiled by CIAT and partners from 2011 to 2014. The dataset is focused on approximately 200 genera inclusive of the world’s major food crops and closely related wild species. The dataset was amassed from online and digital resources from over 100 genebanks, herbaria and researchers, with the broad aims of containing occurrence records for species and providing a comprehensive snapshot of their representation in *ex situ* collections. A portion of the data was directly gathered from herbaria and digitized by the project, and thus represents novel contributions to digital records of crop wild relative occurrences. The database has been carefully curated for taxonomic correctness and has been georeferenced, with geographic locations cross-checked through an established methodology. In total, approximately 5.7 million records are contained, representing by far the largest and most comprehensive dataset devoted to the distribution of the wild relatives of the world's major crops (Figure 2). Within this data, approximately 3.3 million records have verified coordinates that can be used in spatial distribution mapping and modelling. 95.3% of the records in the dataset may be distributed openly to the global community.

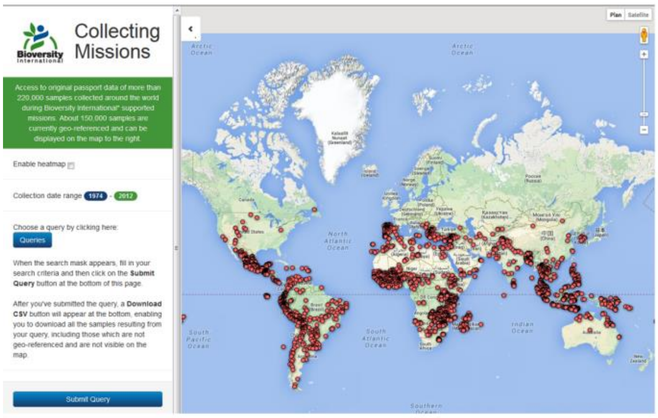
Figure 2. Occurrence data points of crop wild relatives. From the project 'Adapting Agriculture to Climate Change: collecting, protecting and preparing crop wild relatives*'* (authors: CIAT, Global Crop Diversity Trust, Millenium Seedbank Kew, University Birmingham.)

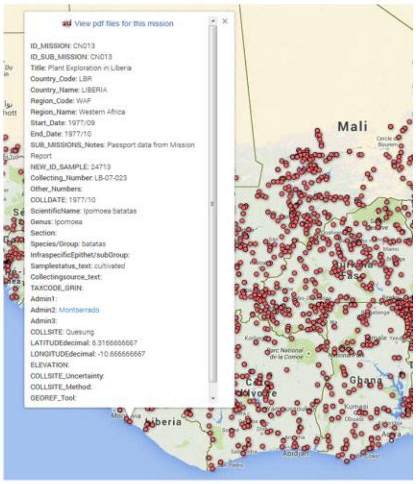


Collecting mission database and fieldbook repositories

From 1974 onwards, expeditions worldwide were organized with the objective of systematically collecting and conserving traditional varieties and landraces cultivated by farmers and the wild relatives of these. Collectors from national and international institutes collected over 225,000 plant samples during more than 500 collecting expeditions to most countries in the world. Samples of approximately 4,300 different species were collected, with a focus on landraces and CWR of major crops. This wealth of landraces and CWR was distributed to over 500 genebanks for conservation. Fieldbooks and reports—where collectors took notes and made sketches about the identification of the plant and its growing environment and valuable farmers' knowledge—were assembled into a collection conserved by Bioversity. To safeguard this collection, which offers an invaluable history of plants that may have been lost from their fields and natural habitats, the fieldbooks have been scanned, indexed using the GBIF standard DarwinCore extended for germplasm and stored in a publicly accessible repository. Passport data of the samples collected along with plant traits were extracted from all these documents and made available online in the geospatial database, using open data standards (Figure 3). GRIN, the USDA genebank catalogue, and the FAO AGRIS 2.0 use this information.

Figure 3. Collecting mission geospatial database. Right: display of the global distribution of the georeferenced collected samples. Left: detail of the passport data of a collected sample and the link to the fieldbook





Atlas of hotspots of agrobiodiversity for the CGIAR Research Programs

This is a series of regional maps displaying the potential richness and distribution of neglected and underutilized species (NUS) produced using species distribution modelling (SDM) tools. Additionally, maps have been produced to show the areas where gene flow is most likely to occur between cultivated species and CWR, creating potential for new diversity *in situ* (Figure 4). This atlas was created by compiling the occurrences obtained from GBIF, SINGER, EURISCO, GRIN and the collecting mission database (Figure 5). Data were curated to improve the taxonomy and the georeferencing and a checklist of NUS was produced. A list of 1,125 taxa was established using different sources like a checklist from Crops for the Future[7]. Only 256 species (43%) from the base list used to produce maps of NUS diversity had more than 30 occurrences. Although limited in predictive power by the overall incomplete eco-geographic data available for NUS, SDM are nevertheless useful for prioritizing future data collection efforts and increasing sampling efficiency (see Guisan et al. 2006, Wisz et al. 2008 and references therein, Elith et al. 2011). Improving data quantity and quality, rather than increasing the complexity of models used, may be an effective way forward for making better predictions on species' geographical distribution (Lobo et al 2008). The study performed to produce the atlas is described in the internal report 'Biodiversity in perspective*'* (Delêtre et al 2012).

[7] http://www.cropsforthefuture.org/about-us/what-are-neglected-and-underutilised-species/

Figure 4. Hotspots of potential geneflow between crops and their wild relatives. Left: global map. Right: focus on Africa (data from: M. Anderssen; map: H. Gaisberger)

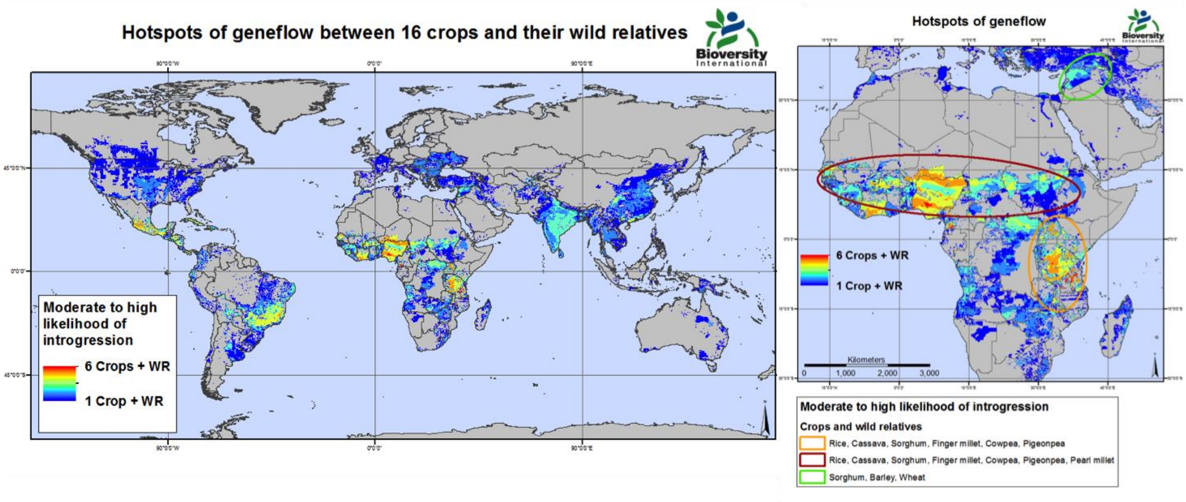
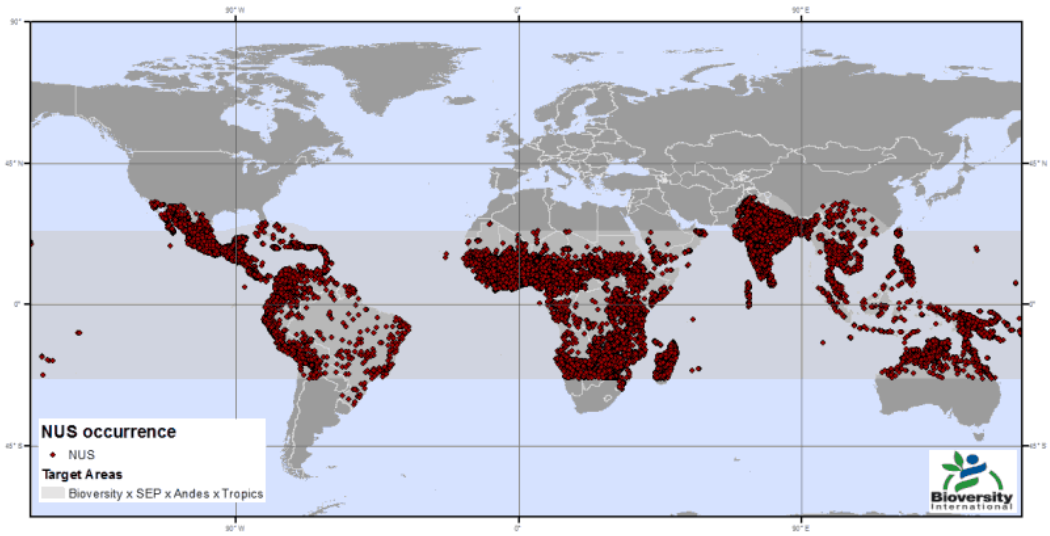


Figure 5. Occurrence of neglected and underutilized species (list of species compiled by M. Deletre; map: H. Gaisberger)



IUCN Red List of Threatened Species™

The IUCN Red List of Threatened Species™ provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria. The Red List aims to catalogue and highlight those plants and animals that face a higher risk of global extinction. Between 94,000 and 194,000 plant species (ca. one fifth of all known plant species) are estimated to be threatened by extinction in the near future (Pitman and Jorgensen 2002). However, the Red List provides data on the conservation status for less than 4%—about 15,000—plant species so far (Schatz 2009).

CWR have thus far not been prioritized for assessment (apart from Solanum species). There is a need to systematically apply the Red List criteria to CWR taxa, commencing with the highest priority taxa within the crop gene pools critical for global food security. Although few CWR taxa have been globally Red Listed, some may be included in national Red Lists, usually because they are nationally rare or threatened and/or endemic species. As part of each country's national CWR strategy, a review of the national Red List (where it exists) should be undertaken to establish whether any of the taxa included are CWR (Maxted and Kell 2009).

Global Agricultural Trials Repository (Agtrials)

The online repository Agtrials contains 34,353 records of crop evaluation trials worldwide along with their GPS references, which enables the geospatial visualization of the sites with access to the data files. Each data file is indexed with metadata describing the evaluation performed (trial, technology, varieties, variables measured, location, etc.). The names of the traits measured during the variety evaluation are selected from the Crop Ontology[8], an online resource compiling breeders' trait dictionaries, to annotate the data files and harmonize the description of the traits. The data file can be publicly available or under restricted access. Each file is attached to a Creative Commons licence.

FAO data resources

The FAO is home to several databases, which serve to support agricultural research for food security worldwide. A selection of these, which would be useful for the purposes of the global information system on *in situ* and on-farm conservation, are the following:

> ***FAOSTAT:*** The statistical database website disseminates statistical data collected as a time-series from 1961 in most agricultural domains for 245 countries.
>
> ***NISM***: The National Information Sharing Mechanism (NISM) is for monitoring the implementation of the GPA. Its objective is to improve countries' capacity to exchange and analyse PGRFA information for future planning. The NISM provides a list of indicators and related questions and a reporting format for monitoring implementation at country level of all priority activities of the GPA. It also supplies guidelines for initiating and coordinating this process and comes with a computer application to facilitate gathering the information.
>
> ***WIEWS:*** WIEWS is the world information sharing mechanism on the implementation of the Global Plan of Action (GPA) for plant genetic resources for food and agriculture (PGRFA).
>
> ***Geonetwork***: The FAO GeoNetwork provides access to interactive maps, satellite imagery and related spatial databases maintained by FAO and its partners to improve access to and integrated use of spatial data and information.
>
> ***The Global Agro-Ecological Zones database (GAEZ)***: The GAEZ Data Portal covers the following thematic areas: 1) Land and water resources; 2) Agro-climatic resources, including a variety of climatic indicators; 3) Suitability and potential yields for up to 280 crops/land utilization types under alternative input and management levels for historical, current and future climate conditions; 4) Downscaled actual yields and production of main crop commodities, yield and production gaps.
>
> ***AGRIS 2.0:*** AGRIS is a multilingual bibliographic database for agricultural science, fuelled by the AGRIS network of 150 institutions from 65 countries, containing more than 7 million records largely enhanced with AGROVOC multilingual thesaurus. It is linked to related data resources on the Web, like DBPedia, World Bank, Nature, FAO Fisheries and FAO Country profiles.

Additionally, there is an important information resource that will enable proper linkages with *ex situ* conservation information:

Genesys

Genesys is a global portal to *ex situ* information about plant genetic resources for food and agriculture. It is the Internet's largest gateway through which users can discover material in genebanks around the world. Genesys brings together accession-level information on genebank collections from many different sources, including passport, characterization and evaluation data as well as environmental information from the sites of collection. The portal allows records from data providers worldwide to be incorporated into one interface, so a single search can span genebanks

[8] http://www.cropontology.org/

around the globe. By facilitating access to and use of these genetic resources, Genesys helps to secure their long-term conservation.

VII. Enabling data interoperability through Linked Open Data

Despite the existence of these international initiatives, and many more at national and regional levels, the informatics landscape remains fragmented with scattered data sources. Development of a culture of data and knowledge sharing using widely and commonly agreed methods, best practices and standards is necessary in order to enable the discovery of data that can support evidence-based decision making. One best practice that could be promoted to the agricultural informatics community is to publish on the Linked Open Data cloud (LOD). LOD practices recommend indexing the elements of information (data, metadata, multimedia support) using agreed terminology and publishing with the resource description framework (standards). This could help harmonize the elements of information that were stored using local formats by creating a reference semantic framework and interoperability.

Metadata, common terminologies, exchange formats already exist and create a basis for a common data interoperability framework. It applies to online datasets, documents, repositories etc. These include:

- Darwin Core including the germplasm extension
- Crop Ontology for traits and agronomy, morpho-taxonomic descriptors and farmer preferences, descriptors for *in situ* conservation of CWR and on-farm conservation
- AGROVOC, FAO thesaurus of agricultural concepts
- Thesaurus of TRY (Plant Trait Database) on ecological traits
- Genomic data standards of the Genomic Standard consortium
- Geospatial standards of the Open Geospatial consortium

A key role of such a LOD system should be to stimulate collaboration between experts, citizen scientists and communities, to:

- Develop, adapt and promote standards, methods, practices for sharing and enabling data comparison
- Access a critical mass of data for developing models
- Engage communities in sharing data and knowledge
- Develop, adapt and promote tools for data mining and discovery

VIII. Conclusion

A global information system on *in situ* conservation and on-farm management of agrobiodiversity is a gap that needs to be urgently addressed by the international communities to complement existing ex situ information systems and provide a means to develop and assess adapted conservation and management strategies of the *in situ* and on-farm diversity that directly influence food security and human nutrition at local levels. The complexity of *in situ* and on-farm diversity conservation and the fragmented status of the information sources mean that collaborative efforts from all stakeholders are necessary. This may also influence how information from these various sources can be organized. Existing global in situ information systems focus on wild plant species. So a broad effort is required to get up to speed with a global information system for PGRFA conserved *in situ* and on farm, integrated with knowledge on why communities value the diversity they use and conserve. It is necessary to expand the mass of accessible data to improve the models and evidence used for decision-making and interventions. To support this objective, stakeholders, including genebank curators, must be actively engaged in the collaborative development of a common framework for integrating data, to participate in the design and content of the envisioned system, to adopt agreed practices that will help identify and describe important datasets.

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