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The scientific information activity of Bioversity International: the descriptor lists

IMPACT ASSESSMENT DISCUSSION PAPER 3

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Abstract

This paper explores the history of descriptor lists (DLs) – scientific standards for documenting plant genetic resources – which have been published by Bioversity International since 1976 (formerly IBPGR 1974-1991; IPGRI 1991-2006). Each DL represents an important tool; together, they constitute the basis for a standardized characterization system that provides an internationally agreed format and universally understood 'language' for plant genetic resources data.

The paper also presents an analysis of data collected through questionnaires and web statistics on the impact of DLs in order to understand their use by major stakeholders. The usefulness of Bioversity's DLs was measured in terms of their value in facilitating the establishment of databases, and improving collaborations and information exchange among organizations. Most survey respondents reported that they not only used Bioversity's DLs, but recognized them as the standards for plant genetic resources data collection and management. Bioversity's DLs are widely respected because they are developed by large groups of crop specialists. Together, the DLs are helping Bioversity to meet the ambitious objective of establishing a Clearing-House Mechanism as set forth by the Convention on Biological Diversity (CBD) Article 18.3, which seeks to promote and facilitate information exchange among parties, Governments and stakeholders in order to assure a full implementation of the CBD. A number of areas for improvement were identified, although some of them are either outside Bioversity's mandate or depend on human or financial capital for implementation.

Keywords: Plant genetic resources, Information, Descriptor list, factor analysis, usefulness.

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Introduction

The value of conserved plant genetic resources is dependent upon the information utilized to promote their use. When Bioversity International[1] was established in 1974, it aimed to promote an international network of genetic resources activities to further the collecting, conservation, documentation, evaluation and utilization of plant germplasm, thereby raising the standard of living throughout the world (IBPGR Annual Report, 1974). This effort required a methodology for describing germplasm accessions that had international approval and was easy to use. To be effective, the methodology needed to correctly describe each accession in order to differentiate between accessions in the same collection and promote collaboration among plant genetic resource (PGR) workers in different countries.

This paper explores the history of descriptor lists (DLs) – scientific standards for documenting plant genetic resources – which have been developed by Bioversity since 1976. Each DL represents an important tool; together, they constitute the basis for a standardized characterization system that provides an internationally agreed format and universally understood 'language' for plant genetic resources data. The adoption of this scheme for data encoding, (and in some cases the creation of a method for converting other schemes to the Bioversity format), helped to create a rapid, reliable and efficient means for information exchange, storage and retrieval to facilitate the utilization of germplasm. This system is particularly important for crops that are covered under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Signatories to the Treaty have agreed to make these crops' germplasm and information about them available to the public for free exchange.

The paper also presents an analysis of data collected through questionnaires and web statistics on the impact of DLs in order to understand the use of these guidelines by major stakeholders.

The historical background and evolution of descriptor lists

Development of standardized descriptors began in 1976, when it became apparent that a universal system was essential for global efforts in plant genetic resource conservation and for networks of genebanks to operate effectively[2]. Bioversity's mandate at the time was to promote and coordinate an international network of plant genetic resources centres in order to further the collecting, conservation, characterization, evaluation and use of these resources.[3] There was no other organization working on plant genetic resources globally, thus it was natural for Bioversity to take the lead in developing methodologies for describing accessions in collaboration with crop-specific CGIAR centres.

Although a few other CGIAR centres were developing descriptors, their collaboration with Bioversity was essential since it was difficult for them to secure the funds required, while Bioversity's mandate allowed it to allocate specific funds from within its own budget for this purpose. Several players were involved in the process of drafting DLs: *Ad hoc* Crop Advisory Groups (CAGs) consisting of crop experts from developed and developing countries were seconded by Bioversity for most major crops and a few minor crops. Sub-committees of CAGs advised Bioversity on collecting and characterization needs in order to develop descriptors. External experts were contracted to ensure that the process was scientifically sound. Bioversity's investment covered expert meetings for developing drafts, editing and other minor work that was required. As Bioversity began working with other CGIAR centres on DLs for mandate crops, some costs and resources were shared, although the bulk of the resources still came from Bioversity.

Since 1990s the funding of DLs has been mobilized indirectly through special project funds from donor grants, which supported the development of DLs to achieve the projects' goals. For example, the Asian Development Bank (ADB), which funded the Tropical Fruit Trees Project, supported the development of mango and litchi DLs, while development of date palm descriptors was funded by the United Nations Development Programme (UNDP)/Global Environment Facility (GEF) through the Date Palm Project. CAGs slowly disappeared because most major crops were covered, funds became more limited to organize meetings and because new developments in information and communication technology enabled collaboration though electronic communication.

An important consideration in the history of the DLs during the 1970s and 1980s is the lack of information-management technologies (IT). In order to build IT capacity, Bioversity supported training of national partners and CGIAR genetic resources scientists at the University of Colorado, Boulder in the use of computers for PGR documentation. This training course in information systems/genetic resources (IS/GR) focused on the use of computers for recording and managing plant genetic resources information. This system was based on the Executive Information and Retrieval (EXIR) system, which was adopted as the Taxonomic Information Retrieval System (TAXIR). These systems, which were based on mainframe computers, became obsolete with the increased use of personal computers and software adapted to PCs.

The concept of crop DLs has evolved over the years in response to changes in users' needs. Initially, DLs

[1] *From 1974 to 1991, Bioversity was known as the International Board for Plant Genetic Resources (IBPGR), and from 1991 to 2006 as the International Plant Genetic Resources Institute (IPGRI). Since December 2006, IPGRI has been operating under the name Bioversity International. We refer to the organization as Bioversity International or Bioversity throughout this paper.*

[2] *There were cases in which plant height was measured by curators in two different ways – from ground level to tip of panicle and to tip of boot leaf – yielding completely different values for the same character. This highlighted the need for standardized and internationally recognized descriptor lists.*

[3] *Little emphasis was placed on use, which was at the time considered a cause of genetic diversity loss through improved varieties with narrow genetic bases and high-yielding capacity.*

provided a minimum set of characteristics to describe particular crops (e.g. *cultivated potato*, 1977). This left many known characteristics without an internationally acknowledged standard description. The idea of minimum lists was revisited in 1990 and a new approach was developed in order to produce comprehensive DLs, which included all characterization and evaluation descriptors (e.g. *sweet potato*, 1991).

The DL format was further revised in 1994 in order to provide users with comprehensive lists containing a minimum set of highly discriminating descriptors (e.g. *barley*, 1994). Since 1995, new standardized sections on *in vitro* conservation, cryopreservation, soil and environment, which were common across different crops and provided users with different options, have been incorporated. Since 1999, ethno-botanical information has also been included (e.g. *taro*, 1999) and is increasingly being standardized.

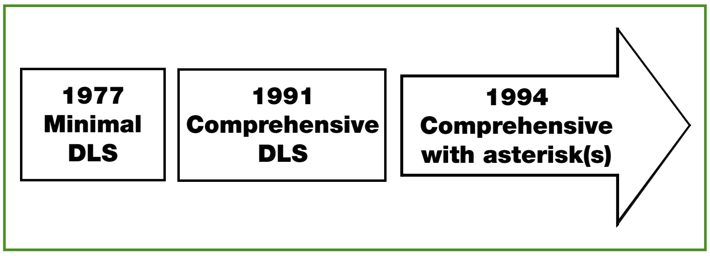

Figure 1. *Evolution of Crop Descriptor List: First Phase (1977-1994).*

The evolution from 'minimal' to 'comprehensive with asterisks' characteristics occurred because several additional traits lacked appropriate internationally accepted definitions, and descriptions were needed to enable communication between institutions. The lack of compatibility in plant genetic resource documentation systems seriously hampered data exchange between collections. Comprehensive and standardized lists allowed better compatibility between documentation systems and facilitated the exchange of information. They also reflected the value attached to traits by PGR researchers and users. Currently, almost all DLs are comprehensive and contain highly discriminating characteristics. (http://www.bioversityinternational.org/Publications/pubseries.asp?ID_SERIE=13 .Viewed on April 2008.)

With the integration of national collections into multi-crop collections, it became evident that common DLs needed to be more consistent across crops. As a result, Bioversity and the Food and Agriculture Organization of the United Nations (FAO), with substantial contributions from European countries and CGIAR centres, published the *FAO/IPGRI List of Multi-crop Passport Descriptors* (MCPD) in 2001 as a subset of passport information contained in the crop DLs. The MCPD provides international standards across crops to facilitate germplasm passport information exchange. For each MCPD, a brief explanation of content, coding scheme and suggested field name is given to assist in a computerized exchange of data. The list has had a positive impact, especially in Europe: most European crop networks now use this list as a basis for developing their central crop databases.

With increased molecular and biochemical characterization of PGR, the need arose to define common standards for documenting information about genetic markers. In order to address this issue, *Descriptors for Genetic Marker Technologies* were published to complement classical agro-botanical analysis (de Vicente *et al.* 2004). This descriptor list includes a minimum set of standards for documenting information about genetic markers. Targeted at researchers who use genetic marker technologies, the publication is meant to facilitate documentation and exchange of standardized genetic marker data. It also provides descriptions of content and coding schemes that can assist in computerized data exchange.

Over the years, a number of useful tools have also been incorporated into the lists to enhance plant genetic resources documentation including phenological scales, colour charts and collecting forms (Banana, 1996 Grapevine, 1997).

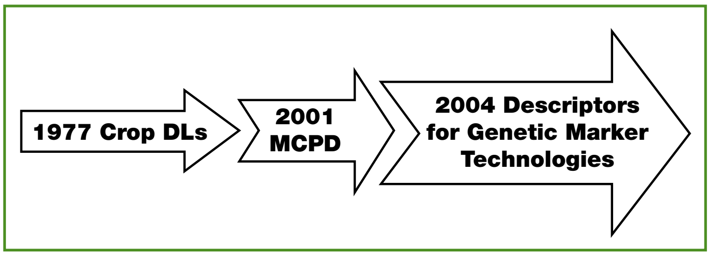

Figure 2. *Evolution of descriptor lists.*

As shown in Table 1 below, production of descriptor lists was highest between 1982 and 1986 when 38 DLs were published. The fewest DLs were published between 1977 and 1981 (12 DLs; 8% of total).

Table 1. Annual Production of Descriptors from 1977 to 2006 *

Year Interval	N. of DLs Published	% of total
1977-1981	12	8
1982-1986	38	25
1987-1991	20	13
1992-1996	31	21
1997-2001	36	24
2002-2006	15	9
Total	150	100

** These figures include multiple publications for the same crop if published in different languages*

As shown in Table 2, 67% of DLs were published in English, but they have also been produced in Spanish, French, Portuguese and occasionally Chinese, Russian, Arabic and Italian.

Table 2. Languages of Descriptors

	1977-1981	1982-1886	1987-1991	1992-1996	1997-2001	2002-2006	Total	% of Total
English	11	36	14	19	14	9	101	67
Spanish	1	1	4	6	10	2	24	16
French			2	6	9	1	18	12
Portuguese					3	0	3	2
Arabic						1	1	>1
Chinese		1					1	>1
Russian						1	1	>1
Italian						1	1	>1
Total	12	38	20	31	36	15	150	

DLs are now comprehensive and indicate highly discriminating characteristics, providing an internationally recognized reference for the majority of known characteristics for individual crops or genepools, along with standardized sections on site and environment, and management. They also include collecting forms and colour charts when relevant. Information contained in the DLs is classified into five main categories to facilitate the maintenance, retrieval and updating of passport, management, environment and site, characterization, and evaluation information.

Passport descriptors provide basic information for the general management of accessions (including registration at the genebank and other identification), and describe parameters to be observed when accessions are collected. They constitute a crucial element in the process of registering germplasm accessions in a genebank.

Management descriptors provide the basis for the day-to-day management of accessions in a genebank and assist with multiplication and regeneration. Genebank curators must ensure that these descriptors are recorded during multiplication, storage, maintenance and regeneration of each accession.

Environment and site descriptors give environmental and site-specific parameters of the locations where collecting, characterization, multiplication and evaluation trials are conducted. They are important for understanding the origins of accessions and for interpreting the results of evaluation trials because interactions between genotype and environment can significantly effect the expression of traits.

Characterization descriptors are observations about plant characteristics that are used to describe an accession and differentiate them from those belonging to other accessions. They provide information that may be useful in crop development and may also help to evaluate claims of novelty for variety protection or plant patents, as in the case of the Union Internationale pour la Protection des Obtentions Végétales (UPOV) Technical Guidelines.

Evaluation descriptors are of great interest to plant breeders for crop improvement and the domestication of new crops. They cover characteristics such as yield, agronomic and other economically important traits, biochemical traits (content of specific chemical compounds, dry-matter content, etc.), and reaction to biotic and abiotic stresses.

Descriptors contribute to increasing knowledge and facilitating research on crops that have received limited attention by the research community, but which are often favoured by poor people. The 100 DLs published over the years include 58 neglected and underutilized species and 55 of the 64 crops listed in Annex 1 of the ITPGRFA. An analysis of reports submitted by 152 countries for the International Conference and Programme for Plant Genetic Resources held in Germany in 1996 indicated that 102 countries were undertaking characterization/evaluation of plant genetic resources and of these, 93 (91%) used Bioversity DLs.

In 1999, the CGIAR Secretariat published a *Synthesis of findings concerning CG Case Studies on the Adoption of Technological Innovations* (Laliberté *et al.*, 1999). The impact study was related to the adoption of descriptors developed for three crops. Of 143 germplasm-collection managers who responded to the survey, 80% indicated that they used DLs in general and 69% used Bioversity descriptors. The remaining 11% used their own descriptor lists or those developed by UPOV or the Council for Mutual Economic Aid (COMECON).

It should be noted that Bioversity DLs and the guidelines developed by UPOV vary significantly. While Bioversity DLs aim to facilitate the documentation and use of plant genetic resources, the UPOV Technical Guidelines assist national authorities in dealing with the registration of new plant varieties. Varieties submitted for testing are evaluated in terms of Distinctness, Uniformity and Stability (DUS). DUS traits form the basis for deciding whether or not breeders can obtain legal protection for a variety (van Hintum *et al.*, 1995). Bioversity DLs facilitate the characterization and evaluation of PGRs that are expected to have considerable genetic variability and therefore not satisfy the DUS criteria, thus requiring a different description system.

Conclusions of the 1999 study included the following:

- "Bioversity (IPGRI) descriptors **are well-known international standards** for the detailed description of crop-specific resources and are used by the majority of germplasm collection managers."

- "Users consider the descriptors to be **very useful** for a range of applications such as characterization, standardization of information, the establishment of databases, documentation of accessions, creation of core collections, data exchange."

According to the 1999 study, the major limitations of Bioversity DLs were related to the lack of: financial resources for documentation activities (53%); human resources for undertaking documentation activities (39%); training and expertise in documentation (44%); and documentation systems (32%). Adoption of the Bioversity DLs was found to have had a positive impact on collection management, with a reduction in duplicate accessions.

Findings indicated that DLs could have a greater impact through more efficient and better-targeted audiences, and by enhancing the understanding of the factors influencing their adoption.

Review of Bioversity's current contribution to descriptors: Survey methodology and respondent characteristics

As a follow-up to earlier studies, a survey was conducted in 2006 to better understand the utility and impact of Bioversity descriptors as part of the Centre-commissioned External Review of Bioversity's Understanding and Managing Biodiversity programme, which coordinates the production of DLs.

A mailing list of respondents was compiled by Bioversity staff based on partners identified in the Annual Project Work Plans from 2001 to 2006 as well as project stakeholders interested in conservation and use of biodiversity (including informatics and forest genetic resources). Names of genebank managers and curators, forestry network members and recipients of programme publications were obtained through organizational databases and added to the list.

Confidentiality of respondents was assured, and the analysis of responses was not linked to any individual respondents; this was conveyed in a cover letter in order to encourage frankness and candour. The survey was delivered to respondents electronically, and if any the respondent was unable to complete the online questionnaire, the survey was sent as an email attachment or faxed document that could be completed offline and returned via fax or email.

A total of 264 individuals participated at the survey (a 48% response rate), but since the survey provided the option of skipping sections, not all respondents answered all survey questions. Approximately one third of respondents who completed the entire survey (90 people) completed the section related to the DLs. Of those who responded, 68% were either directly responsible for germplasm documentation or received training in germplasm documentation, but do not currently practice it. The largest percentage of respondents (46%) described the type of organization in which they work as a research institute, followed by universities (18%), and then by *ex situ* genebanks or other facilities (14%).

In terms of the geographical distribution of respondents' work, the majority were concentrated in Europe and Asia/Pacific/Oceania, followed by South/Central America. The highest number of respondents identified their area of work as conservation, followed by biodiversity management and dissemination, agriculture and biological sciences, crop improvement, and plant breeding. Where possible, the data from the 2006 survey was compared with that of the 1996 study to observe changes over time.

Results of the survey

The surveyors investigated Bioversity's role in promoting and developing scientific standards and management tools for exchange of accession information. The responses suggest that most respondents are familiar with DLs and that Bioversity has made either a significant or some contribution in the field of descriptors dissemination, especially through the development of crop DLs (Table 3).

Table 3. Bioversity's Contribution to standard setting

Type of contribution	Significant	Some	None	No opinion
Development of crop descriptors	65%	20%	4%	11%
Developing and promoting information management tools and methods	55%	33%	1%	11%
Promoting scientific standards for accession information	59%	31%	0%	9%

n=80

Compared with other sources of standards known by respondents, Bioversity descriptors were the best known to the majority of informants (Table 4). When asked to rate the importance of different types of standards, Bioversity's DLs were rated as quite essential (3.3 on a four-point scale), compared with UPOV Technical Guidelines, which ranked below 2.5. Documentation systems developed by genebanks were also rated as important, especially in fields such as germplasm collecting, but the data suggested that genebank documentation systems generally complemented Bioversity descriptors by providing unique standards for particular genebank curators and users.

Respondents' levels of awareness of various DLs are presented in Table 5. Each descriptor's impact is evaluated through a four-point scale, ranging from 1 "not useful" to 4, "very useful".

The results show a strong direct relationship between level of awareness and perceived level of usefulness (correlation coefficientr= 0.83). The highest levels of awareness were recorded for *Multi-crop Passport Descriptors* and *Descriptors for Genetic Marker Technologies* – general descrip-

Table 4. Rating of different DLs by PGR researchers

Field of work	UPOV	Bioversity	Your own	Comecon/ USDA-GRIN
Biodiversity information, management and documentation	2.4	3.9	3.3	2.2
Conservation of germplasm *ex situ* in genebanks	2.6	3.3	3.0	1.6
Conservation of germplasm *ex situ*, other than genebanks	2.7	3.8	2.7	1.5
Forest genetic resources conservation	1.0	3.0	2.0	1.5
Germplasm characterization and utilization	2.2	3.3	2.8	1.6
Germplasm collection	2.0	3.0	4.0	2.0
Molecular genetics/genetic diversity assessment	3.0	3.0	3.0	1.0
Plant breeding/crop improvement	2.3	2.7	2.9	1.4
Other	2.1	3.2	3.0	1.9
Total	2.4	3.3	3.0	1.7

Scale: 1 "not used at all", 4 "Essential" - (n=77)

Table 5. Respondents' awareness and perceived usefulness of descriptors publications

Descriptor Publication	Awareness	Rating
FAO/IPGRI Multi-crop Passport Descriptors	61%	3.5
Descriptors for Genetic Marker Technologies	58%	3.3
Allium (*Allium* spp.)	57%	3.3
Melon (*Cucumis melo* L.)	49%	3.1
Sesame (*Sesamum* spp.)	45%	2.9
Bambara groundnut (*Vigna subterranea*)	43%	2.9
Oca (*Oxalis tuberosa* Mol.)	39%	3.2
Rambutan (*Nephelium lappaceum*)	39%	2.7
Lathyrus spp.	38%	2.8
Ulluco (*Ullucus tuberosus*)	38%	3.2
Pepino (*Solanum muricatum*)	36%	2.8
Litchi (*Litchi chinensis*)	36%	2.8
Jackfruit (*Artocarpus heterophyllus*)	34%	2.7
Mangosteen (*Garcinia mangostana*)	33%	2.6
Palmier dattier (*Phoenix dactylifera* L.)	33%	2.5
Fig (*Ficus carica*)	33%	2.7
Cañahua (*Chenopodium pallidicaule* Aellen)	31%	2.8

Scale: 1 "not useful", 4 "Very useful" - (n=41)

tors that are applicable to all crops. These publications were also rated the highest in terms of utility, (*Multi-crop Passport Descriptors* 3.5; *Descriptors for Genetic Marker Technologies* 3.3). The publication that was known least by respondents was *Date Palm* (*Phoenix dactylifera* L.), probably because it was published only in French. (This DL was published in 2005, and was therefore too new to be known by many survey respondents; nevertheless, its usefulness was rated at 2.5). It must be emphasized that none of the DLs received usefulness values below 2.5.

The usefulness of Bioversity descriptor lists: A factor analysis

In order to further investigate the usefulness of Bioversity DLs, the three main components among the 16 variables reported in Table 6 were extracted from the survey through factor analysis[4]. The usefulness of descriptors was focused on 16 survey's questions; a Principal Components Analysis (PCA) was used to classify dataset responses by three main factors[5]. Answers from 83 respondents were queried and three major components were chosen (Table 6) based on the requisite of having eigen values greater than 1.0; the scree plot and percentage of variance extracted equal 66.96%[6].

The Varimax rotation (Kaiser, 1958) procedure was adopted in order to transform the initial matrix into a

[4] *Factor analysis is used in social science to investigate underlying structure of measurable and qualitative observations. For a bibliography of the applications of factor analysis in the social sciences, see Rummel (1970).*

[5] *PCA is used to transform the data into a new orthogonal coordinate system. The greatest variance from any projection of the data is considered the first coordinate (also known as the first principal component); the second greatest variance is considered the second coordinate, and so on. PCA is generally used to dimensionally reduce datasets by retaining those characteristics that contribute most to its variance by keeping lower-order principal components and ignoring higher-order ones.*

[6] *Nearly 67% of the extracted information is absolutely adequate considering the number of involved variables and the study's purpose.*

Table 6. Total Variance Explained

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.338	45.863	45.863	6.225	38.909	38.909
2	2.012	12.572	58.435	2.378	14.865	53.774
3	1.365	8.529	66.964	2.11	13.19	66.964

Table 7. Rotated Component Matrix

	Variables to be factored	Communalities	Component		
			1	2	3
1-	FAO/IPGRI Multi-crop usefulness	0.365	0.523		
2-	Helped to develop core collections	0.602	0.713		
3-	Bioversity descriptors usefulness	0.633	0.742		
4-	Descriptors enabled greater efficiency in collection management	0.584	0.76		
5-	Increased uniformity of documentation	0.719	0.804		
6-	Contributed to the development and establishment of databases	0.709	0.808		
7-	Bioversity crop descriptors usefulness	0.687	0.819		
8-	Facilitated data exchange	0.732	0.827		
9-	Enabled greater use of accessions by helping potential users	0.743	0.841		
10-	Increased ability to work with other partners	0.754	0.851		
11-	UPOV list usefulness	0.456		0.551	
12-	COMECON list usefulness	0.563		0.727	
13-	YOUR OWN descriptors usefulness	0.57		0.745	
14-	USDA-GRIN list usefulness	0.694		0.756	
15-	Bioversity Descriptors for genetic marker usefulness	0.952			0.955
16-	Bioversity Descriptors for molecular markers usefulness	0.951			0.958

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.

simpler and easier-to-interpret format.[7] Factor scores were subsequently computed for each respondent and used to describe the dataset. As shown in Table 7, a common construct underpinned the set of 16 variables (Hair *et al.*, 1995), which could be factored into three major components without loosing important information obtained from the survey.

The communality values reported in Table 7 show that the quota of each variable's variance is well explained by the three factors. Through the Varimax rotation analysis and the variables included in each factor, the three profiles can be well defined. The factors are labelled as: usefulness generated by the adoption of Bioversity descriptors – including both crop descriptors and MCPD; (*component 1*), usefulness generated by other sources' descriptors (*component 2*); and usefulness of *Descriptors for Genetic Marker Technologies* (*component 3*). The variables measuring the benefits of using Bioversity's descriptors were also examined. Analysis of reported benefits indicated that the descriptors succeed in their main purposes – to facilitate the development of databases, improve information exchange and promote inter-organizational collaboration (see Table 8).

Table 9 shows that the lowest value of usefulness for the Bioversity DLs was given by respondents working in the fields of rural development, social sciences and policy.

Agricultural and biological scientists prefer to use Bioversity crop descriptors and genetic markers, while educators prefer DLs from other sources. This may be because of the technical nature of Bioversity's DLs, which focus on a narrow group of specialists working in genebanks or on specific crops, whereas other DLs are more generic – for training or plant patent protection purposes. These results

7 *After a Varimax rotation, each original variable tends to be associated with one (or a small number) of factors, and each factor represents only a small number of variables.*

Table 8. Reported benefits of the use of descriptors (n=75)

Type of benefit	Major benefit	Some benefit	No benefit
Contributed to the development of databases	64%	32%	4%
Increased uniformity of documentation	62%	37%	1%
Increased ability to work with other partners	51%	40%	9%
Enabled greater efficiency in collection management by helping us to identify and reduce duplication	48%	42%	10%
Facilitated data exchange	47%	43%	10%
Enabled greater use of accessions by helping potential users to select germplasm	42%	48%	11%
Helped to develop core collections	29%	44%	27%

Table 9. Factor regressors according respondent work discipline

Work discipline	Bioversity crop and MCPD DLs	Other source DLs	Bioversity DLs for Genetic Marker technologies
Agricultural & biological sciences	0.11	-0.18	0.08
Conservation	0.18	0.02	0.13
Crop improvement/plant breeding	0.01	0.05	0.05
Education & training	-0.18	0.04	0.20
Extension	0.43	0.17	-0.24
Genetics & genomics	-0.05	-0.07	0.21
Biodiversity information management & dissemination	0.09	0.13	0.02
Policy	-0.18	0.07	0.27
Rural development	-0.52	-0.36	0.20
Social sciences	-0.15	0.43	0.22
Trade and business development	0.29	0.90	0.38

are confirmed by the positive values of usefulness given by those working in the fields of genetics and genomics to genetic and molecular markers, which are strictly related to their disciplines, while they considered crop DLs – both from Bioversity and other sources – as not useful for their work.

Constraints to adoption of DLs

The last part of the survey was dedicated to users' perceptions of the DLs' weaknesses and the possible constraints to their adoption. Although Bioversity's DLs were rated as highly useful, a number of users either modified them based on their needs (47% of respondents), or used them as a reference to develop their own lists (33%). Only 20% of respondents used them *"in their entirety, without adaptations"*. Reported difficulties in using the DLs related to organizational problems such as lack of financial resources for documentation, lack of personnel and lack of a documentation system rather than deficiencies in the descriptors themselves. The most frequently cited constraint to using the DLs was that they did not cover the species of relevance to the respondent (see Table 10). This finding is very similar to the outcome of the 1999 assessment and supports the need for Bioversity's continued involvement in standardization and development of additional crop descriptors. During the intervening period, little has been done to mitigate these constraints to adopting the DLs.

In their survey responses, stakeholders cited some specific wishes, such as harmonization with UPOV DLs. According to plant genetic resources experts however, harmonization of Bioversity's descriptors with the UPOV DLs would not be very useful since Bioversity DLs deal with accessions that show considerable within-accession variation, while UPOV DLs deal with uniform crop varieties. Other respondents noted that Bioversity's DLs miss some phenotypic characteristics that appear in the field, making their adoption difficult. It is, however, important to note that such characteristics may be highly location

Table 10. Constraints to using Bioversity Crop Descriptors (n=58)

Constraints	% response
Bioversity Crop Descriptors did not cover the species of relevance to us	43
Lack the financial resources to undertake documentation activities	39
Lack of personnel to undertake documentation activities	31
Lack of a documentation system in my institute	29
Collections were already documented before Bioversity Crop Descriptors were published	27
Lack of capacity and training to undertake documentation activities	25
Bioversity Crop Descriptors do not adequately describe observed characteristics of the species	25
Bioversity Crop Descriptors were not in the language we need	14
Difficulties in understanding the terminology used in the Descriptors	14
Descriptors do not meet my needs	6
I was not aware of Bioversity Crop Descriptors	8

Table 11. Bioversity Publications Downloads (2001-2006)

Title of Publication	N	Title of Publication	N
FAO/IPGRI Multi-crop Passport Descriptors	847	Colecciones Núcleo de Recursos Fitogenéticos	159
Descriptors for genetic marker technologies	676	DNA banks - providing novel options for genebanks?	146
A Guide to Effective Management of Germplasm Collections	625	Issues on gene flow and germplasm management	142
Análisis Estadístico de Datos de Caracterización Morfológica de Recursos Fitogenéticos	432	*Descriptors for Mangosteen*	137
Design and analysis of evaluation trials of genetic resources collections. A guide for genebank managers resources collections.	391	The Evolving Role of Genebanks in the Fast-developing Field of Molecular Genetics	133
Forest genetic resources conservation and management: In managed natural forests and protected areas *in situ* Vol.2	373	*Descriptors for Bambara groundnut*	124
Core Collections of plant genetic resources	357	*Descriptors for Pepino*	123
Molecular markers for genebank management	314	Challenges in managing forest genetic resources for livelihoods	118
Descriptors *for Melon*	298	*Descriptors for Rambutan*	118
Technical guidelines for the management of field and in vitro germplasm collections	282	A methodological model for ecogeographic surveys of crops	102
In vitro collecting techniques for germplasm conservation	271	*Descriptores del Ulluco*	102
Forest genetic resources conservation and management: Overview, concepts and some systematic approaches Vol 1	259	*Descriptors for Sesame*	84
Forest genetic resources conservation and management: In plantations and genebanks (*ex situ*) - Vol. 3	258	*Descriptors for Lathyrus*	70
Accession management trials of genetic resources collections	244	*Descriptores de Cañahua*	50
Descriptors for Allium	211	*In situ* conservation of wild plant species a critical global review of good practises	46
Descriptors for Fig	193	*Descripteurs pour le Palmier dattier*	39
Descriptors for Litchi	172	Lathyrus germplasm collections directory	12
Descriptortes de Oca	171	Managing Plant Genetic Diversity	2
Descriptors for Jackfruit	182	Total Observations	8,263

specific and therefore cannot be included in internationally accepted DLs. Lastly, as a result of the different time periods of their publication and because the experts groups working on different crops applied different names or standards, Bioversity's DLs were perceived as inconsistent between crops. This is true of most publications that evolve over time. The only possible mitigation strategy would be to undertake a revision of all descriptors in five or six years using a uniform standard. However, this would be a very costly exercise and e-descriptors (Quek, et al., 2005) may help to remedy this situation to some extent.

Web statistics on use of descriptors

End-users' interest in Bioversity descriptors was determined through an analysis of web statistics from 2001 to 2006. Data on web-site use was compiled and reported by CGNet, a private company that provides web services to the CGIAR, including Bioversity International. According to CGNet, there were 8,263 downloads of the 37 electronic publications available on Bioversity's website. Of these downloads, 43.5% concerned Bioversity, with an average of 211 downloads for publications compared to the global average of 223.

Table 11 shows that *Multi-crop Passport Descriptors* and *Descriptors for Genetic Markers Technologies* were the most downloaded publications. This outcome is quite similar to that of the previous survey of stakeholder awareness. End users' most downloaded publications correspond to highest levels of awareness (correlation coefficient ρ= 0.79). *Multi-crop Passport Descriptors* and *Descriptors for Genetic Marker Technologies* represent 10% and 8% of the total, respectively. Taken together, the DLs for individual crops represent 25% of all publications downloaded.

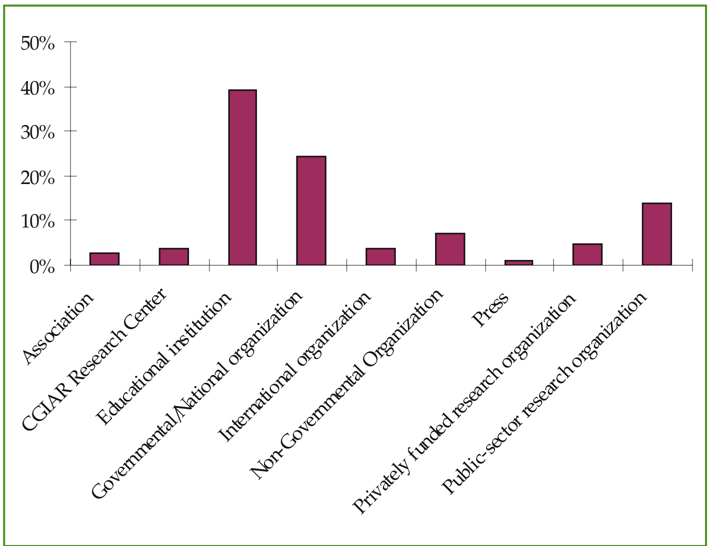

Figure 3. *Descriptor Users.*

The main users of DLs via Internet download (see Figure 3) were educational institutions (e.g. universities), governmental organizations and public sector research organizations. CGIAR centres – some of the most recognized beneficiaries of DL development – accounted for a relatively small percentage, highlighting the varied audience for these electronic publications.

Information was also collected from web visitors regarding the purpose of their downloads. Most reported that their use was for research (see Figure 4), but a surprising number also reported that their use was for consultation and classroom purposes. This was particularly true for respondents in educational institutions, emphasizing the scientific validity and the academic appreciation of Bioversity's work.

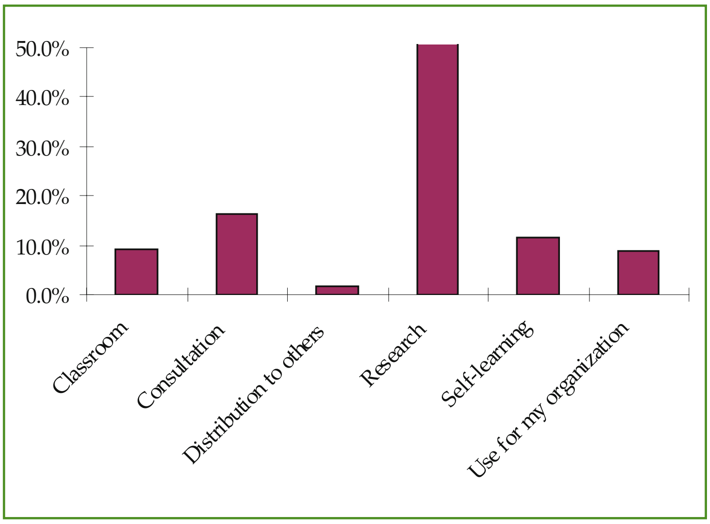

Figure 4. *Download Purposes.*

Figure 5 shows the trend in downloads over a five-year period: total downloads rose over time and peaked in 2004 with the publication of *Descriptors for Genetic Marker Technologies*. During the same period, downloads per publication remained quite steady, which implies that the increasing demand for electronic DLs depends upon on the availability new electronic publications on the web site.

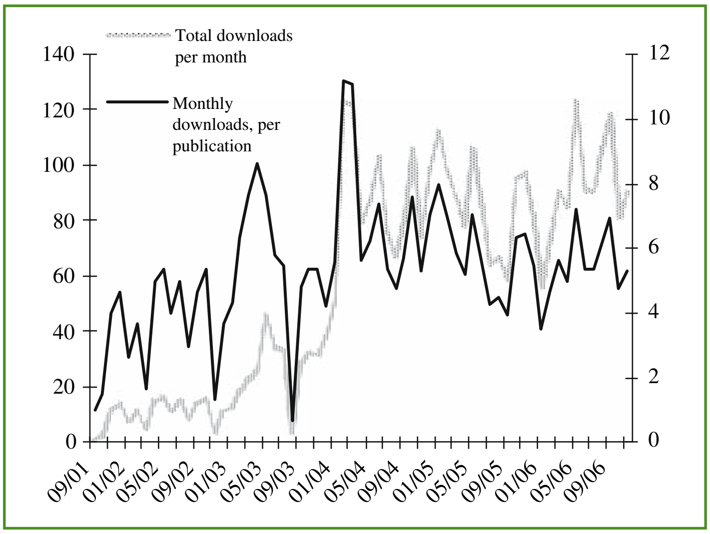

Figure 5. *Trends in Descriptor Downloads.*

Conclusions

The collection, management and utilization of genebank accessions generate a huge quantity of information. A universal and well-defined system for cataloguing and managing the information flow is needed in order to facilitate the management of these accessions and improve access to PGR data (Pank, 2005). Since 1976, Bioversity International has been developing standardized procedures for the characterization, management and evaluation of PGR information, assuring the effective conservation of plant genetic resources and their efficient utilization in crop improvement programmes.

This study investigated Bioversity's activities in the development of genetic resources data standards through descriptor list (DL) publications and assessed the impacts of DLs on users. The survey results indicate that the DLs are indeed being used for their intended purposes. Most survey respondents not only used the DLs, but recognized them as the standards for carrying out PGR data collection and management. These standards are highly respected because they are developed by large groups of crop specialists. The usefulness of DLs was defined in terms of their value in: facilitating the establishment and development of databases; improving collaboration and information exchange among organizations; and finalizing the ambitious objective of building a Clearing-House Mechanism to assure a full implementation of the Convention on Biodiversity (CBD, article 18.3).

Some challenges that were noted in a 1999 survey still remain. However, a number of these constraints are either outside Bioversity's mandate or are due to a lack of human or financial capital for documentation. Bioversity should make additional efforts to determine whether the DLs are being used effectively by those who subscribe to the ITPGRFA, as information exchange on germplasm covered by the Treaty is absolutely needed. Bioversity could also monitor crops included in Annex 1 of the Treaty and develop DLs on additional crops as they are included.

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Abbreviations Used

ADB	Asian Development Bank
APWs	Annual Project Work Plans
CAGs	Crop Advisory Groups
CBD	Convention on Biological Diversity
CCER	Centre Commissioned External Reviews
CGIAR	Consultative Group on International Agricultural Research
COMECON	Council for Mutual Economic Aid
DLs	Descriptor Lists
DUS	Distinctness, Uniformity and Stability
EXIR	Executive Information and Retrieval System
FAO	Food and Agriculture Organization of the United Nation
GEF	Global Environment Facility
IBPGR	International Board for Plant Genetic Resources
IPGRI	International Plant Genetic Resources Institute
ISGR	Information system Genetic Resources
ITPGRFA	The International Treaty On Plant Genetic Resources For Food And Agriculture
MCPD	Multi-crop Passport Descriptors
PCA	Principal Component Analysis
PGR	Plant Genetic Resources
TAXIR	Taxonomic Information Retrieval System
UMB	Understanding and Managing Biodiversity
UNDP	United Nation Development Programme
UPOV	Union Internationale pour la Protection des Obtentions Végétales

Annex 1. List of Bioversity Descriptors published (1977-2006)

List of Multicrop Passport Descriptors (2001). List of Descriptors for Genetic Marker Technologies (2004).

Crop Descriptors:

1. Allium (E,S,F)	2001
2. Almond (revised) * (E)	1985
3. Apple (E)	1982
4. Apricot * (E)	1984
5. Avocado (E,S)	1995
6. Bambara groundnut (E,F)	2000
7. Banana (E,S,F)	1996
8. Barley (E)	1994
9. Beta (E)	1991
10. Black pepper (E,S)	1995
11. Brassica and *Raphanus* (E)	1990
12. Brassica campestris L. (E)	1987
13. Buckwheat (E)	1994
14. Cañahua *(Chenopodium pallidicaule)* (S)	2005
15. Capsicum (E,S)	1995
16. Cardamom (E)	1994
17. Carrot (E,S,F)	1999
18. Cashew (E)	1986
19. Cherry * (E)	1985
20. Chickpea (E)	1993
21. Citrus (E,F,S)	1999
22. Coconut (E)	1992
23. Coffee (E,S,F)	1996
24. Cotton (Revised) (E)	1985
25. Cowpea (E)	1983
26. Cultivated potato * (E)	1977
27. Date Palm (F)	2005
28. Echinochloa millet * (E)	1983
29. Eggplant (E,F)	1990
30. Faba bean * (E)	1985
31. Fig (E)	2003
32. Finger millet (E)	1985
33. Forage grass * (E)	1985
34. Forage legumes * (E)	1984
35. Grapevine (E,S,F)	1997
36. Groundnut (E,S,F)	1992
37. Jackfruit (E)	2000
38. Kodo millet * (E)	1983
39. Lathyrus spp. (E)	2000
40. Lentil * (E)	1985
41. Lima bean * (E,P)	1982
42. Litchi (E)	2002
43. Lupin * (E,S)	1981
44. Maize (E,S,F, P)	1991
45. Mango (E)	2006
46. Mangosteen (E)	2003
47. Medicago (Annual) * (E,F)	1991
48. Melon (E)	2003
49. Mung bean * (E)	1980
50. Oat * (E)	1985
51. Oca * (S)	2001
52. Oil palm (E)	1989
53. Panicum miliaceum and *P. sumatrense* (E)	1985
54. Papaya (E)	1988
55. Peach * (E)	1985
56. Pear * (E)	1983
57. Pearl millet (E,F)	1993
58. Pepino (E)	2004
59. Phaseolus acutifolius (E)	1985
60. Phaseolus coccineus * (E)	1983
61. Phaseolus vulgaris * (E,P)	1982
62. Pigeonpea (E)	1993
63. Pineapple (E)	1991
64. Pistacia (excluding *Pistacia vera*) (E)	1998
65. Pistachio (A,R,E,F,)	1997
66. Plum * (E)	1985
67. Potato variety * (E)	1985
68. Quinua * (E)	1981
69. Rambutan (E)	2003
70. Rice * (E)	1980
71. Rocket (E,I)	1999
72. Rye and Triticale * (E)	1985
73. Safflower * (E)	1983
74. Sesame * (E)	2004
75. Setaria italica and *S. pumilia* (E)	1985
76. Shea tree (E)	2006
77. Sorghum (E,F)	1993
78. Soyabean * (E,C)	1984
79. Strawberry (E)	1986
80. Sunflower * (E)	1985
81. Sweet potato (E,S,F)	1991
82. Taro (E,F,S)	1999
83. Tea (E,S,F)	1997
84. Tomato (E,S,F)	1996
85. Tropical fruit * (E)	1980
86. Ulluco *(Ullucus tuberosus)* (S)	2003
87. Vigna aconitifolia and *V. trilobata* (E)	1985
88. Vigna mungo and *V. radiata* (Revised) * (E)	1985
89. Walnut (E)	1994
90. Wheat (Revised) * (E)	1985
91. Wheat and *Aegilops* * (E)	1978
92. White Clover (E)	1992
93. Winged Bean * (E)	1979
94. Xanthosoma (E)	1989
95. Yam (E,S,F)	1997

Annex 2: List of Crop Descriptors showing coverage of NUS, CG and IT crops

Year	Title	Lang	NUS	IT	CG	Year	Title	Lang	NUS	IT	CG
1977	Cultivated potato	E		X	X	1993	Chickpea	E		X	X
1978	Wheat and Aegilops	E		X	X	1993	Pearl millet	E	X	X	X
1979	Winged bean	E	X			1993	Pearl millet	F	X	X	X
1980	*Colocasia*	E				1993	Pigeonpea	E	X	X	X
1980	Mung bean	E				1993	Sorghum	E		X	X
1980	Rice	E		X	X	1993	Sorghum	F			X
1980	Tropical fruit	E	X			1994	Barley	E		X	X
1980	Yam	E	X	X	X	1994	Buckwheat	E	X		
1981	Lupin	E	X	X		1994	Cardamom	E	X		
1981	Lupin	S	X	X		1994	Walnut	E			
1981	Quinua	E	X			1995	Avocado	E			
1981	Sesame	E	X			1995	Avocado	S			
1982	Apple	E				1995	Black pepper	E			
1982	Lima bean	E	X		X	1995	Black pepper	S			
1982	Oca	S	X		X	1995	*Capsicum*	E			
1982	Phaseolus vulgaris	E			X	1995	*Capsicum*	S			
1983	Cowpea-*Vigna unguiculata*	E	X	X	X	1995	Coconut	E		X	X
1983	*Echinochloa* millet	E	X			1996	Banana	E			X
1983	Grape	E				1996	Banana	F			X
1983	Kodo millet	E	X			1996	Banana	S			X
1983	P. coccineus	E		X	X	1996	Coffee	E			
1983	Pear	E				1996	Coffee	F			
1983	Safflower	E	X			1996	Coffee	S			
1984	Apricot	E				1996	Tomate	F			
1984	Banana	E			X	1996	Tomate	S			
1984	Forage legumes	E		X	X	1996	Tomato	E			
1984	Soyabean	C			X	1997	Grapevine rev.	E			
1984	Soyabean	E/			X	1997	Grapevine rev.	F			
1985	Almond	E				1997	Grapevine rev.	S			
1985	Cherry	E				1997	Pistachio	E	X		
1985	Cotton	E				1997	Pistachio	F	X		
1985	Faba bean	E		X	X	1997	Tea	E	X		
1985	Finger millet	E	X	X	X	1997	Tea	F	X		
1985	Forage grass	E		X	X	1997	Tea	S	X		
1985	Lentil	E		X	X	1997	Yam	E	X	X	X
1985	Oat	E		X		1997	Yam	F	X	X	X
1985	*Panicum miliaceum, P. sumatrense*	E	X			1997	Yam	S	X	X	X
1985	Peach	E				1998	Carrot	E		X	
1985	*Phaseolus acutifolius*	E		X	X	1998	Carrot	F		X	
1985	Plum	E				1998	Carrot	S		X	
1985	Potato variety	E			X	1998	Pistacia-excl. P. vera	E			
1985	Rye and triticale	E	X	X		1999	*Citrus*	E		X	
1985	Sesame	E	X			1999	*Citrus*	F		X	
1985	*Setaria italica*	E	X			1999	*Citrus*	S			
1985	Sunflower	E		X		1999	Rocket	E	X		
1985	*V. aconitifolia* and *V. trilobata*	E		X	X	1999	Taro –Rev.	F	X	X	

Annex 2: List of Crop Descriptors showing coverage of NUS, CG and IT crops (cont.)

Year	Title	Lang	NUS	IT	CG	Year	Title	Lang	NUS	IT	CG
1985	*Vigna mungo, V. radiata*	E		X	X	1999	Taro –Rev.	S	X	X	
1985	Wheat	E		X	X	2000	Bambara groundnut	E	X		X
1986	Cashew	E	X			2000	Bambara groundnut	F	X		X
1986	Strawberry	E		X		2000	Bambara groundnut	S	X		X
1987	Bambara groundnut	E	X		X	2000	Jackfruit	E	X		
1987	Brassica campestris	E	X	X		2000	Lathyrus	E	X	X	
1988	Citrus	E		X		2001	*Allium*	E			
1988	Papaya	E				2001	*Allium*	S			
1989	Mango	E				2001	Banana	E			X
1989	Oil palm	E				2001	Banana	F			X
1989	Xanthosoma	E	X	X		2001	Banana	S			X
1990	*Brassica* and *Raphanus*	E	X	X		2001	Milho	P			X
1990	Eggplant	E		X		2001	*Oxalis*	S			X
1990	Eggplant	F	X	X		2001	*P. lunatus*	P			X
1991	Beta	E		X		2001	*P. vulgaris*	P		X	X
1991	Maize	E		X	X	2002	Litchi	E	X		
1991	Maize	F		X	X	2002	*Pistacia*	A	X		
1991	Maize	S		X	X	2002	*Pistacia*	R	X		
1991	Medicago	E		X		2002	Rocket	I	X		
1991	Medicago	F		X		2003	Fig	E	X		
1991	Pineapple	E				2003	Mangosteen	E	X		
1991	Sweet potato	E			X	2003	Melon	E			
1991	Sweet potato	F			X	2003	Rambutan	E	X		
1991	Sweet potato	S			X	2003	Ulluco	S	X		X
1992	Coconut	E		X	X	2004	Pepino	E			
1992	Groundnut	E			X	2004	Sesame	E	X		
1992	Groundnut	F			X	2005	Chenopodium	S	X		
1992	Groundnut	S			X	2005	Date Palm	F	X		
1992	White clover	E		X		2006	Shea Butter Tree	E	X		
1999	Taro –Rev.	E	X	X		2006	Mango	E			

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