Global Crop Diversity Trust Partnership: Efficient Management of International Crop Collections

Every year, hundreds of new crop varieties are released by breeding programs across the globe to address the affects of pests and diseases, climate change, decreasing yields and many other trends. Taking rice as an example, the statistics presented online by the International Network for Genetic Evaluation of Rice (http://inger.irri.org/released-varieties), suggest at minimum some 100 rice varieties alone are released annually. These varieties may be called "new" but they nearly all represent just novel combinations of traits and genes that exist individually within a spread of varieties of different origins. It is this geographical and biological mixing of traits that underpinned the Green Revolution and provides the agricultural capacity to feed a population of seven billion people (and their livestock) today. Following this line of argument, we can quickly conclude that the sustainability of the massive world populations of the 21st Century are reliant upon the air we breathe, the water we drink, and the crop diversity carefully conserved by a just few expert genebanks across the world.

With its origins stemming from initiatives dating back to the 1980s, the Global Crop Diversity Trust was set up as an independent organization in 2004, by the CGIAR Consortium of International Agricultural Research Centers and the UN Food and Agriculture Organization. The Crop Trust was conceived as an endowment fund mechanism dedicated to provide guaranteed financial support in perpetuity to the most essential of the world's crop genebanks. The Crop Trust implements its work in the framework of the International Treaty for Plant and Genetic Resources for Food and Agriculture (ITPGRFA). An important target for long-term support from the endowment are those *ex situ* collections of the International Agricultural Research Centers ("International Genebanks" from henceforth), which are specifically recognized under Article 15 of the ITPGRFA (Table 1).

Institute	Location	Crops	Number of accessions
Africa Rice	Benin	Rice	19,983
Bioversity International	Belgium	Banana	1,455
Tropical Agricultural Research and Higher Education Center (CATIE)	Costa Rica	Cocoa, Coffee, Tropical Fruit Trees & Various Vegetables	11,385
Centre for Pacific Crops and Trees (CePACT)	Fiji	Edible Aroids, Yams & other Pacific Root & Tuber Crops	1,546
International Centre for Tropical Agriculture	Colombia	Beans, Cassava & Tropical	67,304

Institute	Location	Crops	Number of accessions
(CIAT)		Forages	
International Maize and Wheat Improvement Center (CIMMYT)	Mexico	Maize & Wheat	175,526
International Potato Center (CIP)	Peru	Andean Roots & Tubers, Potato & Sweet Potato	15,756
International Centre for Agricultural Research in Dry Areas (ICARDA)	Morocco, Lebanon & Syria	Dryland Crops & Temperate Forages	146,352
International Cocoa Genebank (ICG)	Trinidad & Tobago	Cocoa	2,400
International Coconut Genebank for African and the Indian Ocean (ICGAIO)	Cote D'Ivoire	Coconut	1,374
International Coconut Genebank for the South Pacific (ICGSP)	Papua New Guinea	Coconut	3,200
World Agroforestry Centre (ICRAF)	Kenya	Fruit & Multipurpose Trees	9,090
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	India	Dryland Cereals & Grain Legumes	119,079
International Institute of Tropical Agriculture (IITA)	Nigeria	Banana, Cassava, Yam, Cowpea, Maize, Bambara Groundnut & Other Legumes	30,388
International Livestock Research Institute (ILRI)	Ethiopia	Tropical Forages	18,716
International Rice Research Institute (IRRI)	Philippines	Rice	121,595

Table 1. International Genebanks under Article 15 of the ITPGRFA.

What makes the International Genebanks different

There may be more than 1750 genebanks in the world according to the FAO[1] but what healthy, viable seed they conserve is not known. Keeping seeds alive is not as straightforward as might be assumed. Some crops have seeds that are easily adapted to long-term storage, but the seeds of most crops store less well, and all seeds die within months or days if conditions are poor. Understanding the needs of

[1] FAO 2010. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture. Rome. (http://www.fao.org/docrep/013/i1500e/i1500e00.htm)

different crops and maintaining stable conditions, year in year out, is key to the efficiency and sustainability of a good working genebank.

The International Genebanks supported by the Crop Trust are at the forefront of seed and plant tissue conservation science, processing and storing collections of more than 100,000 accessions (i.e. millions of seeds), and distributing thousands of samples to requestors around the world every year. Apart from supplying an increasing demand for crop diversity, such large, diverse collections have a unique research interest and very attractive economy of scale. These genebanks are continuously pursuing efficiencies and improvement in their operations.

Long-term storage:
Seed collections are held in cold stores; the "active collection" is held at 4-5°C for use, and the "base collection" is held at minus 18°C for long-term conservation. The maintenance of these facilities incurs a relatively low and stable cost, mainly involving the electricity for running cooling and conditioning equipment. The long-term collection is accessed as little as possible. Individual accessions require regular monitoring for viability. The active collection should be stocked according to demand from users, minimizing the amount of regeneration that is required.

For crops that do not produce seeds but are propagated vegetatively (e.g. banana, potato, cassava, etc), the accessions are conserved as whole plants in the field or as tissue samples in culture in test tubes. These forms of conservation are not only more vulnerable to risks but also demand constant monitoring and care, incurring much more intensive labor and higher costs. Vegetatively propagated collections are, therefore, much smaller and special care is taken to avoid the duplication of accessions. To improve their security and to reduce costs, the International Genebanks have initiated a long-term program to put their vegetatively propagated collections into very low-temperature storage in cryopreservation, where they do not require such intensive care.

Safety duplication:
The International Genebanks which manage seed collections have safety duplicated the majority of their accessions at partner institutes and at the Svalbard Global Seed Vault. The vegetatively propagated collections are not as efficiently duplicated. Duplication takes the form of a partially duplicated set of tissue culture samples that require annual replacement. The progress in cryobanking will change this, and allow the genebanks to undertake a one-off safety duplication of their collections in cryopreserved form.

Regeneration and characterization:
Regeneration is the single most costly activity of a seed genebank. For large collections, several thousand accessions will be planted every year in the field for growing out. Regeneration is particularly costly for outcrossing crops, such as maize, and crop wild relatives, which require careful control in the field, demanding high labour and equipment costs. Given that roughly one fifth of the total non-capital costs of genebanks are devoted to this operation alone, how and what is regenerated and at what frequency is an area for close scrutiny.

There are two main purposes of regeneration: (1) to replenish the seed of accessions that have fallen below acceptable levels of seed viability, and (2)

to multiply stocks of seed that have been used for distribution to requestors. While the second is dependent on the relatively unpredictable factor of demand, the loss of viability can be avoided in various ways. The International Genebanks have state-of-the-art cold rooms with alarm systems that prevent conditions from becoming suboptimal for more than the time it takes for an onsite staff to deal with the problem. However, research shows that seed drying methods in advance of storage and the time taken from harvest to storage also have a strong influence on the viability of the seeds in storage, and that this effect is different for each crop. The International Genebanks are pushing ahead to understand better how to improve seed viability in storage so that less regeneration is needed and the seeds can remain healthy and dormant for longer.

Vegetatively propagated crop collections are not regenerated in the same way as seed accessions but the “trueness-to-type” may be periodically assessed by planting accessions out in the field and characterizing them to ensure they remain true to the original accession. Aging tissue cultures may also require periodic rejuvenation by growing out the whole plant. This type of ‘regeneration’ may prove unnecessary given increased confidence in tissue culture techniques and cryopreservation.

Disease testing and cleaning:

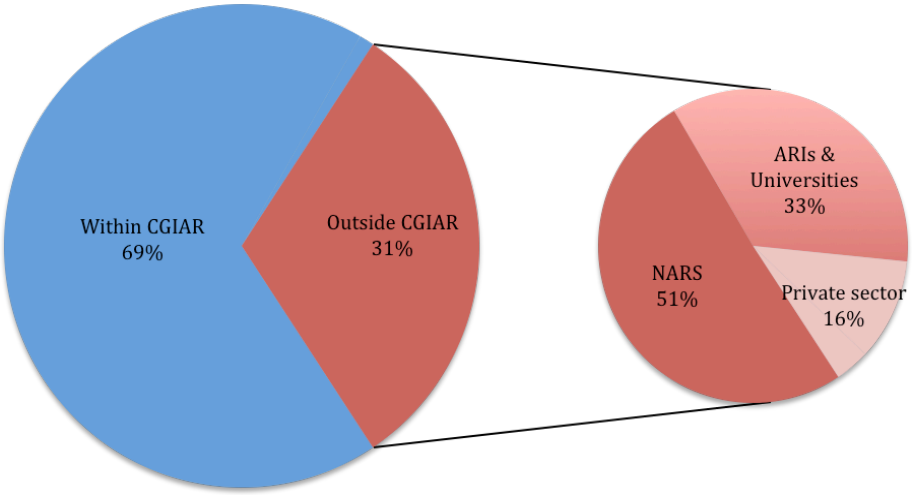
Every CGIAR Center knows that their reputation is pinned on the good health of the seeds that they distribute worldwide. At this level of large-scale, intercontinental exchange, phytosanitary health is of paramount importance. Protocols and procedures for health testing and cleaning evolve almost more rapidly than the pathogens that they detect, and new molecular techniques are taking health testing to new levels of sensitivity. Health testing and cleaning is usually the responsibility of the Germplasm Health Unit within each Center, and costs are charged at a pro-rata rate. For vegetatively propagated crops, the costs of disease cleaning can be particularly high, costing up to US$ 500 per accession, and is only carried out when there are no other options. Host country phytosanitary authorities collaborate closely with, and in most cases depend heavily on, the CGIAR Centers to support their phytosanitary monitoring of international germplasm movement; a clear illustration of the Centers fundamental role in the movement of crop germplasm across the globe.

Introducing new accessions:

The status of each crop collection is highly varied in terms of its global and genepool coverage. There is no one collection that covers the entire crop genepool; all have regional or taxonomic biases. The International Genebanks are continuously attempting to improve the coverage of their collections and, particularly, to identify gaps which are not covered by any other genebank. Crop wild relatives have been highlighted for their lack of representation in collections and efforts are under way, with support from the Norwegian Government, for collecting missions in up to 20 countries. The International Genebanks have recently received several thousand accessions from national genebanks for safety duplication as part of a Gates-funded project coordinated by the Crop Trust. This project rescued unique accessions in 246 collections in 77 countries worldwide.

Dissemination:

The International Genebanks account for more than 90% of the distribution of germplasm in the multilateral system of the International Treaty. Recently there has been a trend for countries to request thousands of accessions from the International Genebanks to form the foundation stock of newly built national genebanks. Just in the past two years alone more than 270,000 samples have been disseminated by International Genebanks to 128 countries (Figure 1). This represents the only source of clean and documented germplasm for myriads of research projects, breeding programs, evaluation trails, in some cases even variety releases, development programs and more.



154,894 germplasm samples disseminated by CGIAR Genebanks to 102 countries in 2013

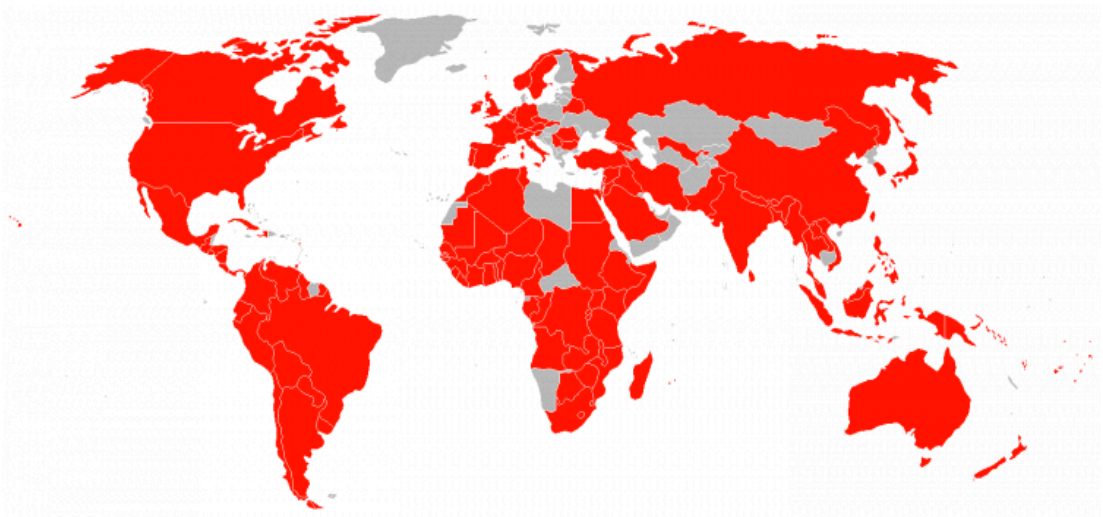


Figure 1. Distribution of germplasm from CGIAR Genebanks within the CGIAR and worldwide to different users.

Managing information on accessions:
Every genebank manages accession data for two major objectives: (1) to manage the collection appropriately, and (2) to ensure all the vital characteristics of each individual accession are available to inform the user of their value and potential use. All International Genebanks have developed barcoding mechanisms to improve accession management. Digital imagery, mapping, characterization and evaluation data and now genotyping and sequencing all contribute importantly to enhancing accession identification and use. The International Genebanks and their associated researchers and partners continue in the mutual quest to improve the quality and quantity of accession-level data and to explore the depths of the collection for traits that have the potential to unlock key breeding constraints.

Genesys (http://www.genesys-pgr.org), managed by the Crop Trust, is the global portal for accession-level information, providing access to data on 3 million accessions held in more than 350 collections, facilitating data exchange and cross-searching. Users can search across all this material for combinations of passport, characterization, evaluation and climatic descriptors, and request the resulting material from the appropriate genebank. Work is planned to add evaluation data, and bring new national and regional genebanks on board as partners. Genesys is a central component of the global information system of the International Treaty.

Determining the costs of running a genebank

A landmark study on the economics of conserving crop genetic resources in five of the CGIAR genebanks was undertaken and published in the early 2000s[2]. This study provided the first estimates of the costs of maintaining genebanks in perpetuity. Various factors have since influenced these estimations, including the adoption of international standards of operation.

A second costing study commissioned by the CGIAR Consortium and the Crop Trust took place in 2010[3]. This study used the data from an economics-based decision support tool, developed at IFPRI[4], which required costs to be assigned for individual activities (e.g. acquisition, characterization, long-term storage, etc.) on each crop collection within each Center. The aim was to account for costs as comprehensively as possible. Information gathered included:

- The capital cost of facilities/infrastructure, as well as associated financial information such as the acquisition date and service life of infrastructure and equipment, and country inflation and discount factors for determining present value of the capital stock;
- The capital cost of all equipment needed for the genebank (not only equipment capitalized by Centers in accounting terms, but all equipment regardless of cost);
- The permanent staff costs associated with relevant genebank operation ("quasi-fixed costs");
- Variable costs for labor – wages or fees paid to temporary workers and others such as consultants who worked within a given year;

[2] Koo, B, PG Pardey and BD Wright. 2004. Saving Seeds: the Economics of Conserving Crop Genetic Resources Ex Situ in the Future Harvest Centres of the CGIAR. CABI Publishing. Kings Lynn, UK and Cambridge, Massachusetts
[3] Shands, H., Hawtin, G. and MacNeil, G. (2010). The Cost to the CGIAR Centres of Maintaining and Distributing Germplasm.
[4] http://cropgenebank.sgrp.cgiar.org/index.php/management-mainmenu-433/decision-support-tool-mainmenu-142

- Non-labor variable costs – these include various operating expenses including supplies, office and lab expenses, travel, computer charges, facility cost charges, farm operation expenses, and so on.

For comparability, costs were determined on a per accession basis and were divided into recurrent costs (costs for activities that take place every year or that could be annualized) and “one-off” costs that occur only once (at least in theory) in the “life” of an accession, such as acquisition, characterization and introduction into tissue culture or cryopreservation. Other one-off costs for the overall optimization of the collection were also separated, such as the need to eliminate backlogs in regeneration, or to bring all of a collection into long-term storage. Centers maintaining collections of the same crops were compared to determine any underlying factors leading to differential costs and to rationalize among Centers to the extent possible. Overhead and capital costs were taken into account to the fullest extent possible although more accurate methods to fully recover costs have since been implemented by nearly all Centers.

Summary of Annual Costs (in US$) for Maintaining and Distributing the CGIAR Germplasm Collections

	Annual recurring cost per accession	Total Annual recurring cost	Annual cost for additional 1% accessions	Total annual capital costs	ANNUAL TOTAL COST	Adjusted by 2% for Inflation
AfricaRice						
Rice	10.06	201,147	14,858	119,794	335,799	**342,515**
Bioversity						
Banana and Plantain	652.50	846,946	41,492	63,456	951,894	**970,932**
CIAT						
Beans	19.48	699,226	90,407	177,521	967,154	**986,497**
Cassava	71.88	473,806	25,687	102,552	602,044	**614,085**
Tropical Forages	26.82	620,664	0	157,770	778,434	**794,003**
Centre total		1,793,696	116,094	437,843	2,347,632	**2,394,585**
CIMMYT						
Wheat	16.96	473,499	107,984	28,072	609,555	**621,746**
Maize	3.28	418,863	34,805	79,335	533,023	**543,683**
Centre total		892,362	142,789	107,407	1,142,578	**1,165,430**
CIP						
Andean R&T	146.50	171,987	9,179	16,289	197,455	**201,404**
Potato	171.49	1,236,951	86,319	149,284	1,472,554	**1,502,005**
Sweet Potato	151.75	1,230,335	159,630	107,896	1,497,881	**1,527,839**
Centre total		2,639,273	255,128	273,469	3,167,890	**3,231,248**
ICARDA						
Barley	5.65	151,685	16,362	43,295	211,342	**215,569**
Chickpea	6.09	81,953	10,681	35,358	127,992	**130,552**
Faba Beans	6.09	55,892	6,180	49,811	111,883	**114,121**
Forage and Range	6.72	165,248	0	82,921	248,169	**253,132**
Grasspea	6.03	19,347	1,872	11,815	33,034	**33,695**
Lentil	6.09	67,014	6,986	22,975	96,975	**98,915**
Pea	6.03	36,614	4,688	18,504	59,806	**61,002**
Wheat	7.14	283,703	24,303	77,213	385,219	**392,923**
Centre total		861,456	71,072	341,892	1,274,420	**1,299,908**
ICRISAT *						
Chickpea	10.74	217,743	21,446	30,815	292,354	**298,201**
Groundnut	12.74	196,838	18,630	26,939	422,607	**431,059**
Pearl Millet	12.49	277,332	35,107	28,811	540,570	**551,381**
Pigeon Peas	12.86	175,356	22,277	17,688	245,221	**250,125**
Small Millet	15.75	161,182	20,346	12,164	227,992	**232,552**
Sorghum	10.20	387,122	47,484	48,547	687,353	**701,100**
Centre total		1,415,573	165,290	164,964	2,416,097	**2,464,419**
IITA						
Banana	66.24	19,209	0	9,317	28,526	**29,097**
Cassava	70.00	194,817	7,516	62,331	264,664	**269,957**
Cowpea	11.15	185,359	20,072	223,578	429,009	**437,589**
Maize	12.12	10,638	1,545	16,301	28,484	**29,054**
Misc. Legumes	11.78	51,184	4	47,488	102,674	**104,727**
Yam	63.93	214,797	11,436	28,862	255,095	**260,197**
Centre total		676,004	40,573	387,877	1,108,452	**1,130,621**
ILRI						
Tropical Forages	32.95	623,449	0	200,828	824,277	**840,763**
IRRI						
Cultivated Rice	7.36	782,571	123,566	205,485	1,111,622	**1,133,854**
Wild Rice	21.27	95,672	19,997	139,008	254,677	**259,771**
Centre total		878,243	143,563	344,493	1,366,299	**1,393,625**
SYSTEM TOTAL		**10,828,149**	**990,859**	**2,442,023**	**14,935,338**	**15,234,045**

***** ICRISAT: Total collection costs include costs (US$670,270) of maintaining collections in Africa

Table 2. Summary of the costs of the CGIAR Centers in 2010 used as the basis to determine the current genebank budgets.

The results of this Costing Study (Table 2) are now used as the basis for current levels of funding to the CGIAR Centers for the routine operations of the genebanks. A number of important activities are still not included, such as collecting new material, identification of duplicates (except in the case of some collections of vegetatively propagated crops), evaluation, pre-breeding, research on conservation methods, networking, providing international leadership, training and public awareness.

The evolution in genebank costs between these studies and over the last decade is striking (Figure 2). The early economic studies appear to have seriously underestimated the real costs of carrying out genebank operations to an adequate level. Aside from the depreciation of the US dollar, two main factors underpin the apparent doubling or tripling of genebank costs: the real change in costs to support higher standard of facilities and operations and the accounting of the full utility and service costs incurred by the genebanks.

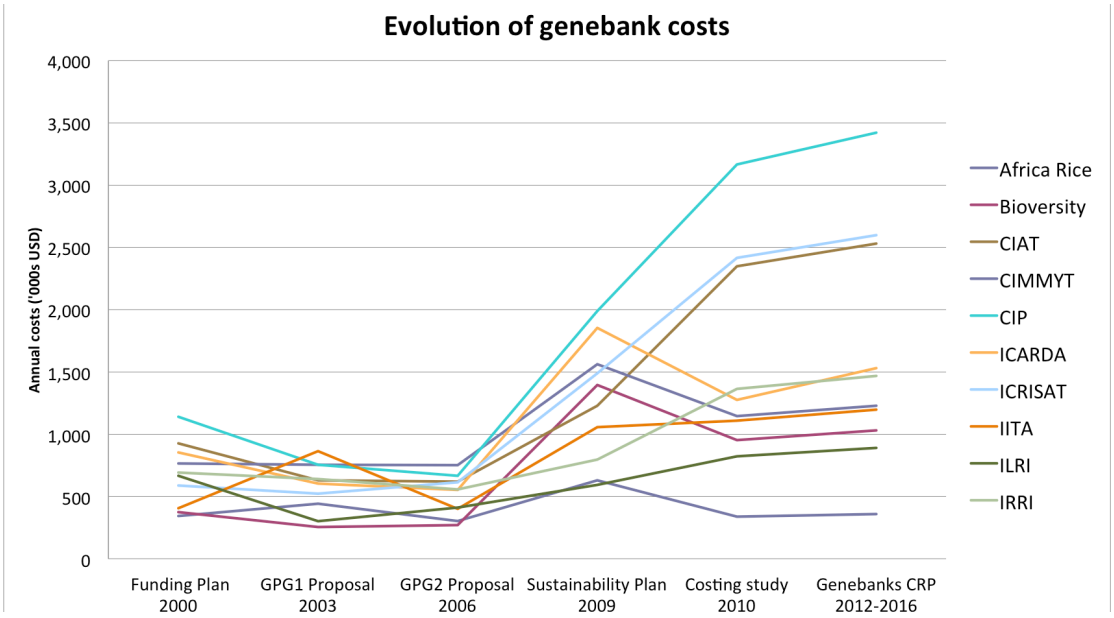


Figure 2 Evolution of the total costs of managing a genebank according to different estimations

Five of the 16 International Genebanks under Article 15 of the ITPGRFA are not part of the CGIAR Consortium. They have not been comprehensively costed in the same way as the CGIAR Centers. The nature of these collections are also quite different from typical genebanks: four of them (CATIE, ICG-Trinidad, ICGAIO and ICGSP) manage probably the most challenging crops to conserve, namely Cacao, coconuts and coffee, which cannot be kept as seed and present additional challenges in field collections due to their long generation span and the difficulties of carrying out controlled pollination (even with the aid of very tall ladders). There are further important genebanks that have not committed to the conditions of Article 15 but hold collections of global importance. These include the Ethiopian Institute of Biodiversity, N.I. Vavilov Research Institute of Plant Industry in Russia, the World Vegetable Centre (AVRDC) and the Breadfruit Institute at the National Botanical Gardens in Hawaii. We can only roughly estimate the costs of managing these collections.

There are many reasons why some genebank operations are less or more expensive than others, including the:

- Biological nature of the crop – this may be the most significant single factor;
- Location of the genebank – local labour costs vary significantly;
- Local markets and circumstances affecting unit costs (e.g. inflation, local currency valuation, and input costs such as electricity and materials/services, etc.);
- Size of operation – there are economies of scale affecting total costs;
- Institutional factors such as organizational structure and scale of overall activity may affect cost recovery metrics resulting in different costs at different locations.

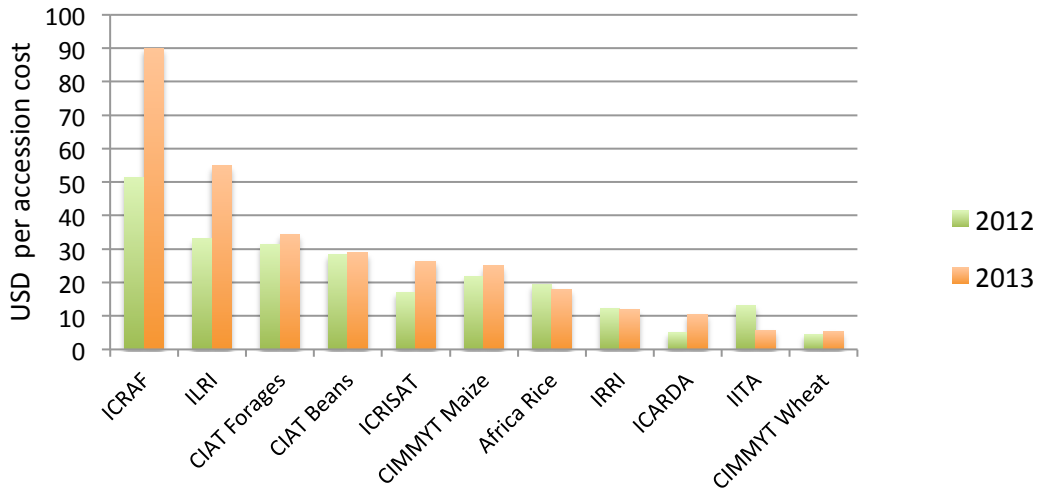


Figure 3 Per accession costs across seed collections managed by the CGIAR

These differences in costs between genebanks are illustrated in per accession costs (Figure 3). The Crop Trust is embarking on an exercise to refine these costs further with a particular aim of achieving a satisfactory level of equivalency and sustainability in both standard of performance and budget allocation across all institutes. Together with the CGIAR Consortium Office, we are developing a proposal for the CGIAR Fund Council, which will present future financing and management options for the genebanks. The first step in ensuring equivalency is for every genebank entering into a long-term agreement with the Crop Trust to reach common performance standards. More is said about performance standards in the section below on “What is the role of the Crop Trust?” The Crop Trust is also working to determine the basic specifications of a genebank working to international standards. The aim of this study will be to provide a reference for the minimum staffing, facilities, equipment and supply requirements of an International Genebank. These specifications can be modified according to the size and type of collection, and then local costing structures may be applied to derive a budget estimate for individual genebanks. Further, a ceiling of 15% is being applied across all agreements with the Crop Trust for indirect costs, beyond which only direct costs will be accepted.

Partner institutes also contribute, both financially and in kind, to the long-term sustainability of the genebanks that they manage. In the long-term agreements, partner institutes are asked to contribute to the annual budget, the equivalent of 25% of the value of the grant in matching funds, which may be put towards the long-term sustainability and use of the collection. This may cover long-term infrastructure needs or investments in research and conservation activities that are not included in the funded routine operations.

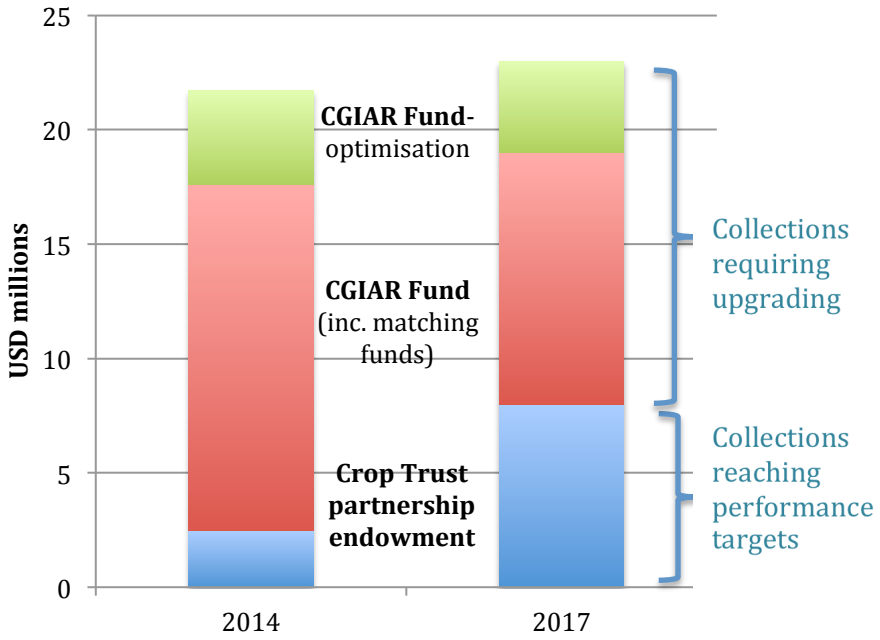


Figure 4. Endowment funding will be provided to genebank reaching performance targets

Over the next five years we envisage that the cash in the endowment, currently at USD 180 million, will increase to a First Phase target of USD 500 million. In parallel with the growth in the endowment will be the gradual improvement of International Genebanks to reach performance targets. As more Genebanks become eligible to receive long-term funding, the annual income from the endowment will take over an increasing proportion of the financing needs for routine operations (Figure 4).

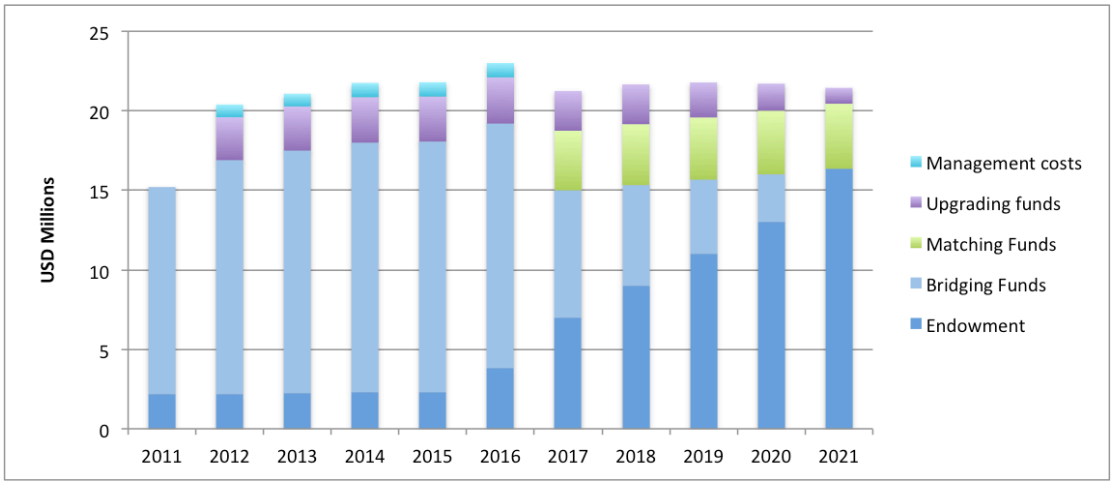


Figure 5. Annual funding to the CGIAR genebanks between 2011 and 2021

Looking solely at the CGIAR Genebanks, in 2014 the endowment covered approximately 15% of routine operating costs and the CGIAR Fund covered the rest (Figure 5). This current phase of funding finishes at the end of 2016, after which we envisage that a declining sum of "Bridging Funds" will be requested of the CGIAR Fund as genebanks reach performance targets and become eligible for long-term funding from the endowment. By 2021 the funding will be provided entirely from the endowment plus the matching funds from the partner institutes. We anticipate that, although the overall level of funding will not change markedly, allocations to

individual genebanks are likely to be modified as performance and quality management are improved and mechanisms to ensure equivalency across Centers are implemented.

What is the role of the Crop Trust?

The Crop Trust plays much more than a financing role. Our overall aim is to ensure security in the world's food supply. For this we need to build a stronger global community of genebanks and genebank users – a "Global System" – linking the International Genebanks more closely with each other, and with national and regional partners and users worldwide. We are achieving this through a number of ways, and most particularly by:

- **Fund raising and financing partnerships to address critical constraining issues** (e.g. collecting crop wild relatives, regeneration and rescue of unique accessions, etc.);
- Building and promoting the global information portal, **Genesys**, and coordinating the new initiative, **DivSeek**, to develop shared methods, tools and standards for managing Big Data to promote the use of crop diversity;
- **Facilitating the development of Global Crop Conservation Strategies and User Groups** within communities of specialist conservationists, researchers and users, which will help to define priorities and influence financing decisions;
- **Monitoring and providing oversight to the International Genebanks**.

Until recently, very little external monitoring or review of the International Genebanks was taking place. The Crop Trust set up its first long-term agreement with an International Genebank in 2007. Agreements followed with other institutes, and a common set of performance management indicators was established to monitor the annual status and progress of the operations in these funded genebanks. In 2012, the CGIAR Consortium requested that the Crop Trust expand its role and provide financial and technical oversight to the entire group of eleven CGIAR Genebanks under a five-year Program for Genebanks. This provided a welcome opportunity for the Crop Trust to consolidate its monitoring and grant management approaches in anticipation of its intended role as manager of a full endowment fund. In close consultation with genebank managers, we have developed a management framework, which has aligned the CGIAR Genebanks for the first time under a single, unified monitoring and financing system.

Online Reporting Tool:

Detailed accession figures are reported for the first time on an annual basis in an Online Reporting Tool created and managed by the Crop Trust. For annual monitoring, the dataset comprises roughly 250 fields of enquiry concerning most aspects of accession and data management, as well as of the security of the facilities, staffing and annual costs (Figure 6). One of the finer points of the tool is it allows correspondence to occur between the Crop Trust and genebank staff on individual questions or tables so that the information submitted can be questioned and improved before the report is finalized. Once approved, the reports are made publically available at https://grants.croptrust.org. The data feeds into performance indicators and provides important background information for expert reviews.

Financial reporting and review are also carried out using the same online tool. Annual funds for routine operations are fixed over a five-year period and deviations from submitted budgets are carefully assessed taking into

consideration any changes or implications affecting technical performance. In this way, technical and financial monitoring are as closely linked as possible, and any unforeseen changes in costs or operations may be managed to ensure that the smooth running of the genebank is not adversely affected. Most importantly, the genebanks are assured of a known budget over a five-year period, which facilitates efficiency and planning enormously and has provided the genebanks an unprecedented period of stability and growth.

IRRI | Performance indicators | 2013 | Annual report | Rice

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ARS.02 TABLE AS4 - Seed collection accession numbers

Total number of accessions	Live plants	LTS	MTS	Total number accessions counting individual accessions only once	Summed total
In the costed collection	4	119,050	120,985	121,595	240,039
Legally available within the costed collection	4	114,150	116,086	116,695	230,240
Genetic stocks within the costed collection	0	3,547	6,060	6,087	9,607
With health status tested	0	101,399	102,213	102,311	203,612
Health tested in 2013	0	5,133	6,105	6,120	11,238
With health status clean	0	101,399	102,181	102,311	203,580
Disease cleaned in 2013	0	195	208	208	403
With known viability		119,050	120,828	121,553	239,878
Tested for viability in 2013		15,939	20,887	28,453	36,826
With acceptable viability		116,445	119,643	120,285	236,088
Regenerated (because of low viability) in 2013		16	54	57	70
With acceptable seed number		114,515	118,532	121,593	233,047
Subjected to seed increase in 2013		1,640	6,247	6,281	7,887
Legally and physically available	4	0	113,190	113,194	113,194

Comments 3547 should be a final figure for genetic stocks in LTS, because policy is now not to store genetic stocks in LTS.

Figure 6. Screenshot of one of the questions in the annual technical report on the Online Reporting Tool. Data in highlighted cells feed into performance indicators.

Performance indicators, targets and self-imposed challenges

The International Genebanks that enter into an agreement with the Crop Trust for long-term funding have obligations to meet specific eligibility criteria (Table 4), which are laid out in the Fund Disbursement Strategy[5].

Summary of eligibility criteria
Each holder: ✓ commits to long term conservation and availability ✓ works in partnership towards the global system ✓ has links to users ✓ has HR & management system to maintain PGR ✓ can demonstrate conformity with agreed standards ✓ has facilities that are adequate for long-term storage

Table 4. Eligibility criteria for collections funded through the endowment mechanism

[5] http://www.planttreaty.org/sites/default/files/gb3i08e.pdf

They have committed to make available their collections and the associated data under the Multilateral System of Access and Benefit Sharing according to Article 15 of the ITPGRFA. Under the same Article, the Genebanks are bound to "manage and administer these ex situ collections in accordance with internationally accepted standards, in particular the Genebank Standards[6], as endorsed by the FAO Commission on Genetic Resources for Food and Agriculture". The Crop Trust has put in place performance indicators and quality management systems to demonstrate these commitments.

Focussing on the International Genebanks' commitment to make collections and related accession-level data available in perpetuity, the Crop Trust and CGIAR Genebank Managers have agreed four major performance targets, which must now be clearly met and maintained before full funding is provided from the endowment fund (Table 5).

		Indicator	Targets or Challenges
TARGETS	1	**Availability:** % collection which is clean (of seed-borne pathogens of quarantine risk), viable, in sufficient seed number to be made immediately available for international distribution from medium term storage	90% accessions in the current costed collection
	2	**Security:** % collection held in long-term storage conditions in two locations and also in the Svalbard Global Seed Vault. For clonal crops the target is for 50% of the collection to be held in cryopreservation in two locations, with an intermediary target of 90% of the collection to be held in slow growth conditions *in vitro* in two locations	90% accessions in seed collections 90% accessions in *in vitro* collections (long-term target 50% accessions in cryopreservation)
	3	**Data availability**: % collection with minimum passport and/or characterization data available online	90% accessions in the collection
	4	**Quality Management System** (including risk management and user satisfaction)	Minimum elements of QMS are in place.
CHALLENGES	5	**Distribution of diversity**: number of discrete accessions distributed in a single year and over a ten-year period	To ensure that a significant proportion of the diversity in the collection is explored and used.
	6	**Distribution of samples**: number of samples disseminated in a single year and over a ten-year period	To increase distribution to more countries and more users
	7	**Increased efficiency**: examples include days between harvest and storage; years since previous regeneration, duration between subcultures for clonal crops – **to be refined**	Increase storage efficiency
	8	**Cost per accession:** per accession cost of routine genebank operations	Maintain costs per accession within an appropriate range, comparable with other genebanks

Table 5. Performance targets and challenges

[6] Citation: FAO. 2014. Genebank Standards for Plant Genetic Resources for Food and Agriculture. Rev. ed. Rome. (http://www.fao.org/docrep/019/i3704e/i3704e.pdf)

The targets dictate that 90% or more of the accessions in collections are immediately available for distribution, secured in safety duplication and documented online. A number of further so-called “challenges” for more proactive distribution of germplasm, improved efficiency and cost-effectiveness are planned to be imposed individually by the genebank managers themselves. These challenges will not constrain eligibility for full endowment funding but they may be incorporated into a mechanism for performance-related funding.

According to the most recent data provided in the ORT, only one CGIAR Center meets these performance targets (Figure 6). Functioning at routine rates of activity, several genebanks would require more than 15 years of work (whilst halting all acquisition and distribution) to reach performance targets of 90% availability and safety duplication. Through the CGIAR Genebanks Program, the genebanks are, thus, accelerating regeneration efforts and upgrading their collections. By 2016, we expect more collections will have reached performance targets for availability, and all CGIAR Genebanks will meet all targets by 2021.

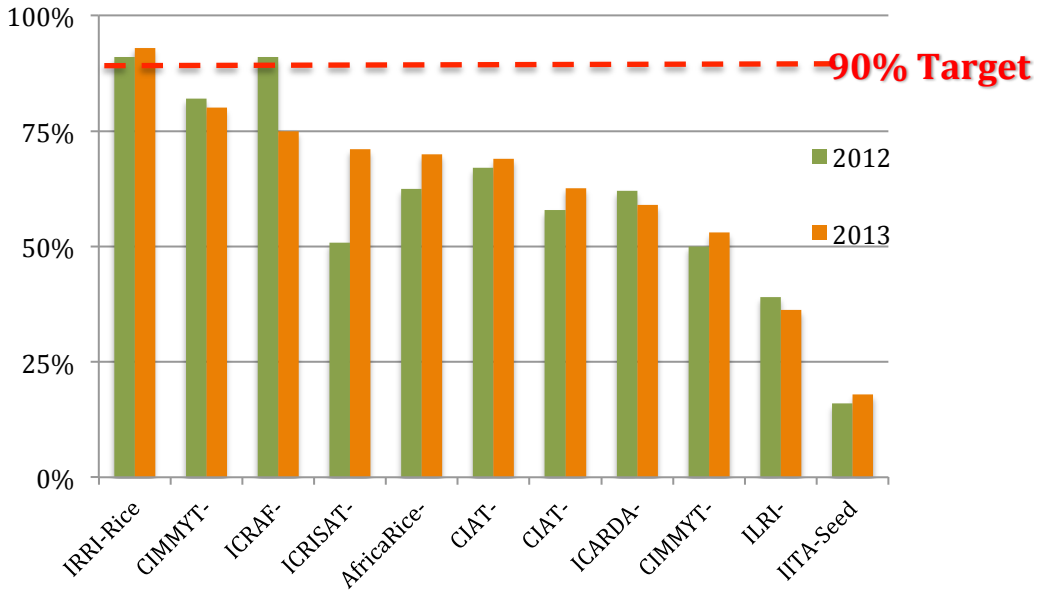

Figure 6. Status of availability of CGIAR Center Genebanks in 2012 and 2013

The status of the clonal crop collections requires special mention because the long-term conservation of crops such as sweet potato, banana, cassava and yam still demands the breaking of technical frontiers. While many aspects of medium term conservation have become routine, the protocols are still being built to produce and conserve botanical seed, to diagnose and eliminate viruses, culture meristems and to successfully cryopreserve different genotypes. Not only are the clonal crop collections further from performance targets, but the targets are also lower. The CGIAR genebanks are now working towards the cryopreservation of their clonal collections as the only means for providing a level of long-term security to parallel that of the seed collections. After many years of investment, around 10% of the clonal crop collections are secured in cryopreservation. Protocols and standards continue to be improved but this effort will require significant investment for at least a further ten years.

Quality Management System:

The Crop Trust believes that a regularly reviewed and validated quality management system (QMS) is essential to demonstrate the conformity to international standards and the commitment of genebanks to the sustainability of high-level quality operations, including staff training, health, safety and succession and comprehensive risk management. Several genebanks in Europe and the CGIAR have pursued externally led QMS such as the ISO 17025:2005 for the accreditation of laboratory processes. The Crop Trust has decided to hire a full-time QMS specialist to develop a unique QMS tailored specifically to genebanks and incorporating all genebank operations. Through a step-by-step approach, the CGIAR Genebanks will be brought to a minimum level of QMS by the end of 2016. A framework has been developed, which brings documented procedures, policies, international standards, performance targets and best practices, which influence specific genebank operations (acquisition, storage, regeneration and distribution), all together into one set of Standard Operating Procedure (SOPs). The system also differs from other QMS by depending heavily on the open exchange of information, with any genebank being able to adopt elements that may be better developed elsewhere in another genebank. A number of shared staff training events are planned to facilitate this exchange and collaboration between genebanks. Each genebank will, eventually, customize its own set of SOPs to local conditions, the training and involvement of staff being of key importance. Mechanisms to regularly review and externally validate the SOPs will be put in place. QMS has a powerful role in empowering staff, most particularly numerous staff who have dedicated more than 30 years to understanding and conserving these unique resources and are able to pass on some of their knowledge and expertise through properly documented procedures. Perhaps most importantly, a regularly validated QMS can provide confidence to donors and partners that the institutes they are investing in are following the highest possible standards of conservation.

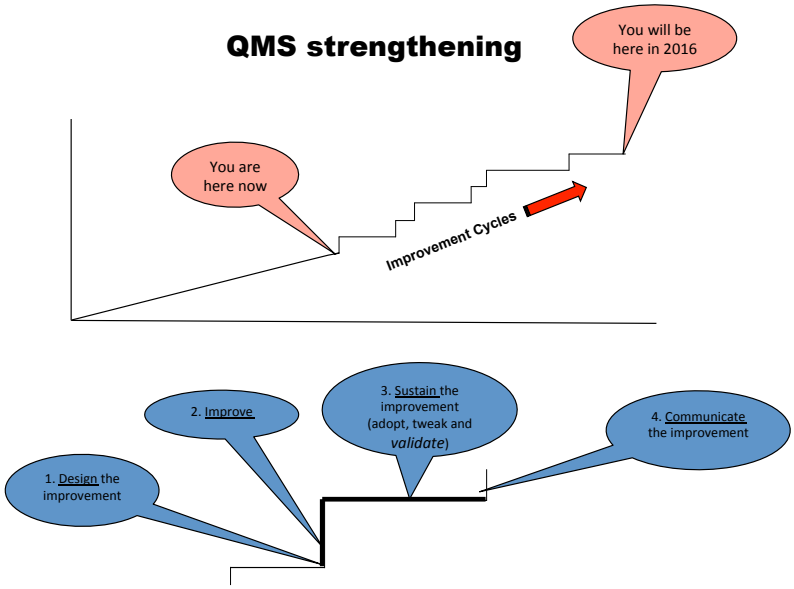

Figure 1 Improvement cycle in QMS

5-yearly expert, external review:

External genebank reviews commenced in 2012. Eight of the eleven International Genebanks have since been reviewed. The reviews are carried out by two or three experts in genetic resources conservation and use, with facilitation from Crop Trust staff. The reviewers assess the operations, procedures and activities of the genebank, as well as the broad composition of the collection and its use. The reviews held so far have provided valuable endorsement of the uniqueness, standards of operation and role of the International Genebanks. The data from the ORT have encouraged the

reviewers to examine genebank operations in detail. As a result, important recommendations have been made for improving the efficiency and security of the reviewed genebanks. The reviewers' report, once finalized, is made generally available and presented for discussion at the Annual Genebanks Meeting. A budgeted Recommendation Action Plan is developed by the Center, which becomes the basis for funded activities to address recommendations.

To highlight some of the work currently underway as a result of reviews:

- CIMMYT is successfully regenerating, for the first time, accessions of Highland maize, which originate from the Andes and demand unusual conditions to regenerate, in two new high-altitude sites in Mexico;
- ILRI is investing institute funds in constructing a new genebank building and cold rooms;
- Bioversity is putting in place new health and safety measures and equipment in its cryobank;
- CIMMYT is collaborating with ICARDA to regenerate wheat crop wild relatives in suitable conditions in their center of origin;
- ICRISAT is revamping its entire data management system and improving the profile of the genebank on its web site.

The list continues.

In conclusion

The words of one of the reviewers might be applied to any of the International Genebanks: "*This genebank rightly has a strongly positive international reputation for the conservation of germplasm… The bank appears to stand at a cross-road. A successful future depends on it being used to its maximum potential. The continued support through the Crop Trust of the Genebanks Program is essential if this globally important facility is to thrive*".

Our firm belief is that the future of the human population depends on our food supply, and so depends on the availability of crop diversity as a basis for sustaining and improving agricultural productivity. The Crop Trust Partnership is working hard to ensure that International Genebanks thrive and serve fully the breeders, researchers and farmers of today and tomorrow. We invite you to join the Partnership, support our work and have a say in what we do.