2020 ANNUAL REPORT

CGIAR Genebank Platform

CGIAR Genebank Platform

CROP TRUST

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Acronyms

AFS CRP	Agri-Food System CGIAR Research Program
AfricaRice	Africa Rice Center
AGM	Annual Genebanks Meeting
Alliance-CIAT	International Center for Tropical Agriculture
BMZ	Federal Ministry of Economic Cooperation and Development (Germany)
CBD	Convention on Biological Diversity
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CoP	Community of practice
Crop Trust	Global Crop Diversity Trust
CtEH	Crops to End Hunger Initiative
CRP	CGIAR Research Program
DArTseq	Diversity Arrays Technology Sequencing
DOI	Digital Object Identifier
EiB	Excellence in Breeding Platform
EMBRAPA	Brazilian Agricultural Research Corporation
FAO	Food and Agriculture Organization of the United Nations
FTA	CGIAR Research Program on Forests, Trees and Agroforestry
GCO	Genebank Costs & Operations
GHU	Germplasm Health Unit
GLDC	CGIAR Research Program on Grain Legumes and Dryland Cereals
GLF	Global Landscapes Forum
GLIS	Global Information System
GOAL	Genebank Operations and Advanced Learning
GPA	Global Plan of Action
GRIN	Germplasm Resources Information Network
GWAS	Genome-Wide Association Study
IA	Intellectual Assets
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	World Agroforestry (International Council for Research in Agroforestry)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IEA	Independent Evaluation Agreement
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
IPPC	International Plant Protection Convention
IRRI	International Rice Research Institute
ISI	Institute of Scientific Information
ITC	International *Musa* Germplasm Transit Centre
LPA	Long-Term Partnership Agreement
MELIA	Monitoring, Evaluation, Impact Assessment and Learning
MLS	Multilateral system of access and benefit-sharing
NARES	National Agricultural Research Extension and Education System
NARS	National Agricultural Research System(s)
NGO	Non-governmental organization
NPGS	USDA National Plant Germplasm System
ORT	Online Reporting Tool
PDCI	Passport Data Completeness Index
PGRFA	Plant Genetic Resources for Food and Agriculture
Plant Treaty	International Treaty for Plant Genetic Resources for Food and Agriculture
QMS	Quality Management System
RTB	CGIAR Research Program on Roots, Tubers and Bananas
SDG	Sustainable Development Goal
S4R	Seeds4Resilience
SGSV	Svalbard Global Seed Vault
SMB	System Management Board
SMO	System Management Office
SMTA	Standard Material Transfer Agreement
SNP	Single Nucleotide Polymorphism
SOP	Standard Operating Procedures
SQM	Seed quality management
USDA	United States Department of Agriculture
W1/2	Windows 1 and 2

Front and back cover art by Sophie Munns for the Crop Trust Legacy Awards

Genebanks adapted rapidly in 2020 to enable staff to continue to perform critical operations while ensuring they did not contribute to spreading COVID-19. Photo: Peter Wenzl/Alliance-CIAT

Key Results

1.1 Highlight Global Progress and Achievements

CGIAR germplasm distribution continued despite COVID-19

The Genebank Platform supports the activities of the CGIAR genebanks and germplasm health units (GHUs) to conserve and make available crop, forage, and tree genetic resources, contributing to UN Sustainable Development Goals (specifically Target 2.5). The year 2020 was an extraordinary year with lockdown measures affecting genebank operations and demand for germplasm, as well as other areas of research and delivery. All genebanks and regions were impacted to some degree, however, those located in Latin American countries experienced the longest and strictest lockdown conditions. Despite this, by the end of the year, a total of 43,530 germplasm samples (36,661 accessions) were distributed by CGIAR genebanks to users (Figure 1), which represents around half the amount of germplasm distributed in a normal year. The total number of requests from external users was reduced by more than a quarter, reaching 889 requests in 2020, of which 91% were successfully concluded during the year.

Consistently over the last four years, germplasm distribution to requesters outside CGIAR has exceeded distribution to CGIAR programs. In 2020, 75% of germplasm distributions went outside CGIAR to recipients in 78 countries. Lower-middle income countries received the largest proportion (49%) of

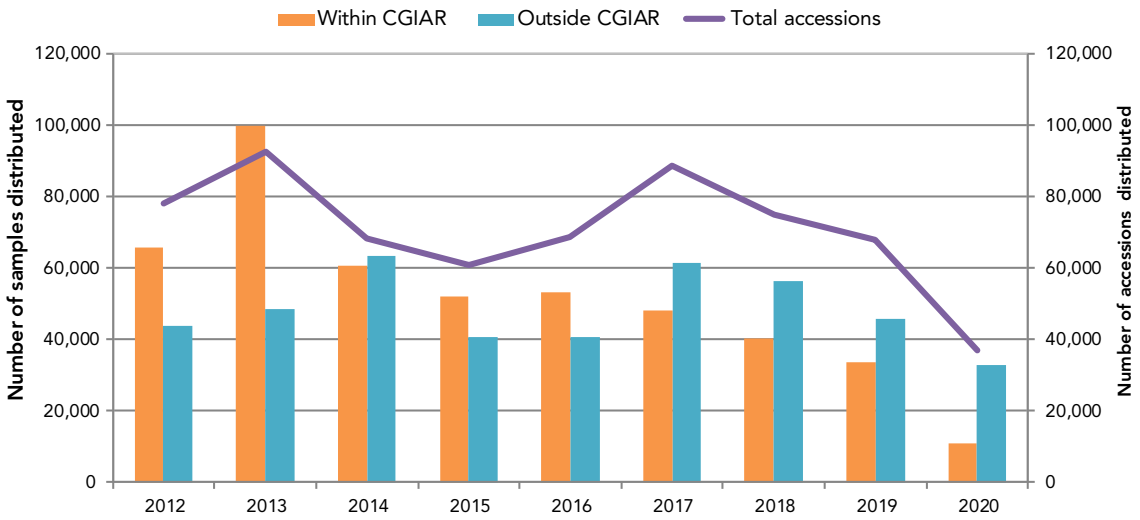


Figure 1. Samples and accessions distributed annually by CGIAR genebanks from 2012 to 2020

germplasm shipments in 2020 (Figure 2). Annex Figures 1 to 4 provide more details of the distribution of germplasm to countries by Center and crop. Of the external distributions in 2020, 42% of samples were sent to universities or research institutes, 31% to National Agriculture Research Systems (NARS), the rest to the commercial sector, NGOs, farmers and others (Annex Figure 2). Most samples (78%) were traditional cultivars or crop wild relatives (Annex Figure 3). Table 1 lists the top country recipients of germplasm from CGIAR genebanks (not including materials transferred within or between CGIAR Centers).

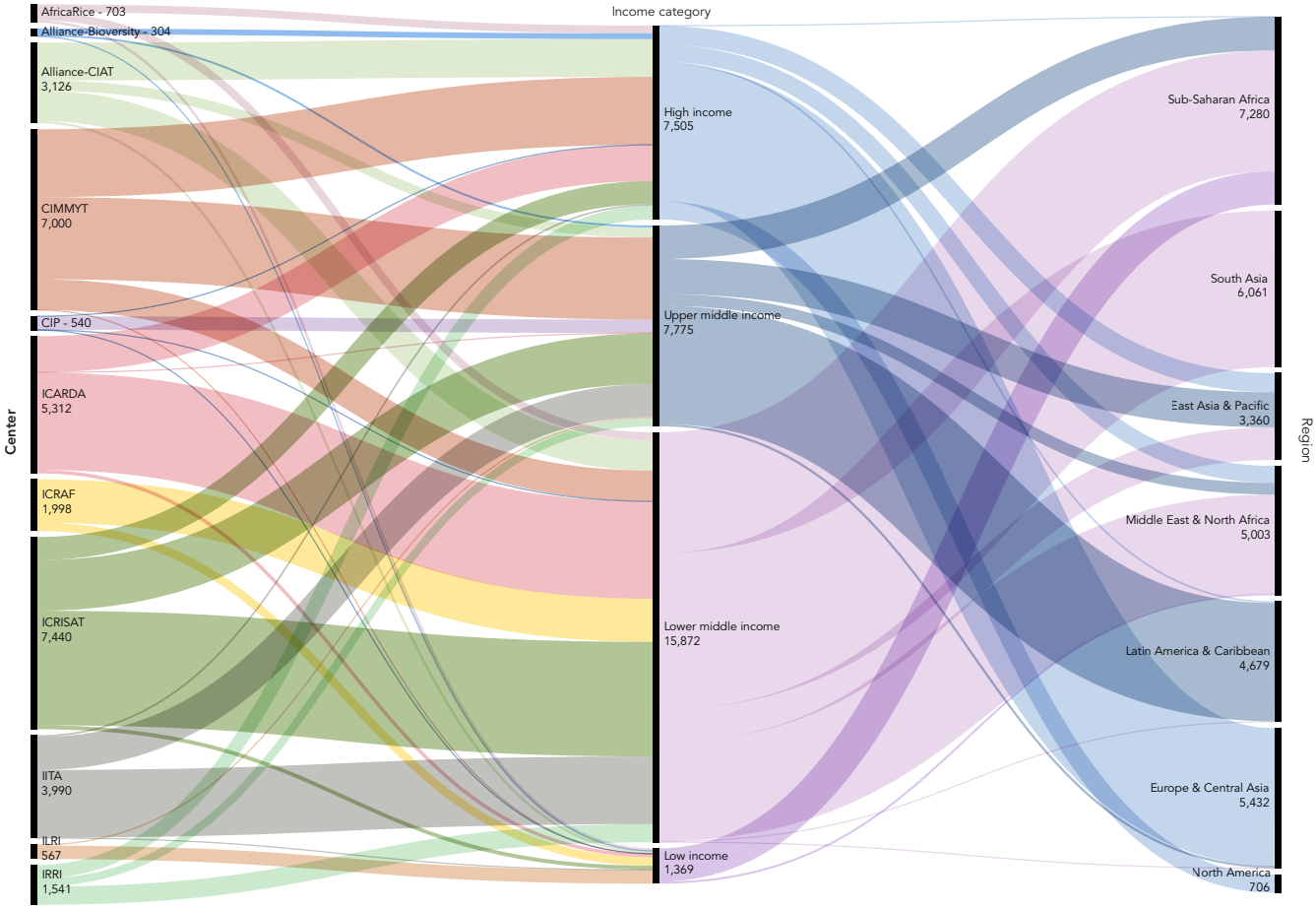


Figure 2a. Distribution of germplasm from CGIAR genebanks in 2020 (excluding distributions to CGIAR programs) Notes: Income and regional categories based on World Bank classification. See Annex Figure 1 for geographical distribution by Center.

Figure 2b. Countries (blue) receiving germplasm from CGIAR genebanks in 2020

1.2 Platform Progress towards Outputs and Outcomes

1.2.1 Overall Platform progress

By the end of 2020, CGIAR genebanks were managing a total collection of 736,210 crop, forage and tree accessions, including 26,224 *in vitro* accessions and 32,930 accessions held as trees or plants in the screenhouse or field. Approximately 82% of the total collection is acceptably viable, free of quarantinable disease, with adequate stock and legally available for international distribution (Figure 3).

Of the seed accessions, 60% is secured in safety duplication at two levels and 78% is duplicated at the Svalbard Global Seed Vault (SGSV). 65% of clonal crop collections is safety duplicated in the form of cryopreserved or *in vitro* cultures (Figure 3).

The yearly increases, since 2012, in total accession numbers, and numbers available and safety duplicated are provided in Table 2. The target for both availability and safety duplication is 90%. Table 3 reports the achievement of milestones.

Table 1. Top 10 countries receiving germplasm from CGIAR Centers in 2020 (excluding distributions to CGIAR programs)

Rank	Lower-middle income & Low income economies			Upper-middle income & High income economies		
	Country	Number of Accessions	Number of Samples	Country	Number of Accessions	Number of Samples
1	India	4,086	5,184	Brazil	2,052	2,056
2	Morocco	2,793	2,793	Italy	1,332	1,337
3	Nigeria	2,078	2,692	China	1,334	1,335
4	Cameroon	74	1,133	South Africa	1,190	1,297
5	Ethiopia	730	730	Mexico	1,127	1,266
6	Pakistan	717	720	Spain	1,195	1,195
7	Vietnam	136	680	Czech Republic	718	718
8	Algeria	617	617	United States	618	643
9	Lao, P.D.R.	99	495	Peru	316	493
10	Kenya	128	473	Colombia	226	469
	Sub-total	**11,458**	**15,517**		**10,108**	**10,809**
	(% from total)	**89%**	**90%**		**70%**	**71%**
	Others	1,452	1,724		4,378	4,471
	(% from total)	11%	10%		30%	29%
	Total	**12,910**	**17,241**		**14,486**	**15,280**

Notes: Ranking by number of samples. Income categories based on World Bank classification

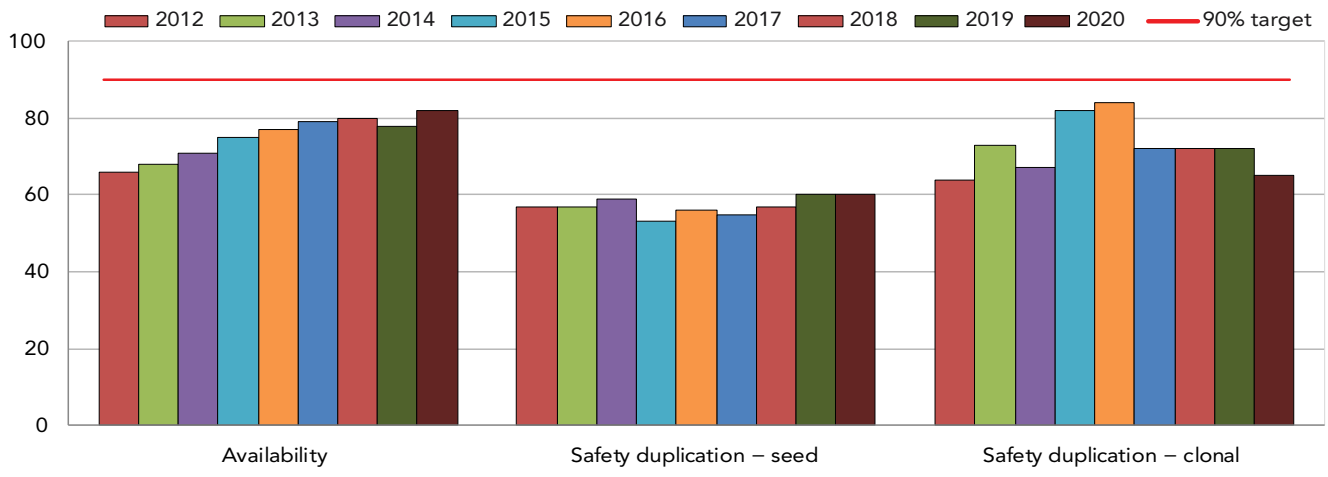


Figure 3. Status (%) of availability and safety duplication of CGIAR genebanks from 2012 to 2020 (Target 90%)

Table 2. Key statistics of the aggregate CGIAR collection from 2012 to 2020

Indicator	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Total number of accessions	710,001	725,244	738,215	750,604	757,767	768,576	773,402	760,467	736,210
2. Total number of accessions that are immediately available	465,358	492,654	525,410	559,053	580,706	608,751	621,915	592,118	601,811
3. Seed accessions held in long-term storage and safety duplicated at two levels	386,037	375,271	413,448	381,932	404,074	408,323	420,164	439,206	432,910
4. RTB accessions in cryopreservation or safety duplicated at one level	15,643	16,141	15,554	19,356	19,803	18,144	18,427	18,524	16,964

Table 3. Summary of status of Planned Outcomes and Milestones

Milestone	2020 milestones status	Completed milestones or explanation for extended, canceled or changed
Conservation Module		
Outcome 1.1: Disease-free, viable, documented germplasm made available All genebanks and germplasm health units are working towards attaining or sustaining 90% targets of availability and safety duplication.		
1. 81% accessions available	82% (completed)	Online reporting tool (ORT)
2. 62% seed accessions safety duplicated	60% (extended)	Several Centers were able to safety duplicate samples but a number were forced to delay shipments because of lockdown conditions. ICARDA also continues to recall safety duplicates from the Svalbard Global Seed Vault in order to reconstitute the collections. (ORT)
3. 75% clonal accessions safety duplicated	65% (extended)	Duplication of clonal accessions severely impacted by lockdown restrictions. (ORT)
Outcome 1.2: Crop diversity conserved in a rational and effective global system All genebanks are working on improving quality management systems and assessing and improving the representation of crop gene pools within collections managed by the CGIAR.		
4. Historical viability re-testing data collated and analyzed	(completed)	Hay et al. scientific paper to be published in 2021
5. Representation of 22 crop genepools in *ex situ* conservation quantified	(completed)	(https://www.genesys-pgr.org/c) rice, beans, lentil, wheat, barley, cowpea, sorghum, maize, finger millet, pearl millet, pea, grasspea, groundnut, faba bean, *Medicago*, chickpea, Bambara groundnut, sweetpotato, taro, cassava, banana, potato
6. Comprehensive revised cost analysis	(completed)	Genebank Costs & Operations (GCO) report
Use Module		
Outcome 2.0: More effective access and use of germplasm enabled All genebanks are working to promote the use of collections through improving data associated with accessions, data quality and its availability.		
7. Novel query interfaces available based on phenotypic, genetic and environmental data linked to genebank accessions	(extended)	Subsetting tool under development by Alliance-CIAT and ICARDA for retrieving phenotypic and environmental data in Genesys. Beta version will be available Q1 2021 (https://www.genesys-pgr.org/datasets)
8. At least three focal subsets assembled and genotyped by each genebank	(completed)	https://www.genesys-pgr.org/subsets
Policy Module		
Outcome 3: Supportive policy environment developed The Policy Module of the Genebank Platform continues to work to ensure that the activities, guidelines and reporting processes of the genebanks comply with legal requirements and the CGIAR engages in the development of international policy.		
9. Centers policy compliance decision making tool	(completed)	To be made available in CGSpace in 2021
10. CGIAR annual report on intellectual assets management and Centers' public disclosures about licenses and IP applications for improved germplasm include information relevant to Plant Treaty's Governing Body	(completed)	https://www.cgiar.org/food-security-impact/intellectual-assets-reports/
11. Reports to CBD/Nagoya Protocol COP, and expert working groups	(completed)	To be made available in CGSpace in 2021

1.2.2.a Progress by module
Conservation Module

As collections are growing and seeds stocks are gradually being used or losing viability, sustaining or reaching performance targets depends on keeping up an optimal rate of operation to ensure collections remain adequately stocked. The progress of individual genebanks in reaching targets is presented in Figure 4 and Table 4. Despite the lockdowns' effect on operations, the numbers of available accessions increased in all genebanks in 2020 except IRRI, which sustained its 90% target. Six out of 10 seed collections have now reached the 90% availability target. CIMMYT and Alliance-CIAT were able to archive materials thanks to a new CGIAR Guidance Note on Improving Accession Management (see Policy Module), which has reduced the total size of collections under their management and brought them closer to the performance targets. AfricaRice, Alliance-CIAT and IITA genebanks also improved safety duplication status through shipping accessions for safety duplication.

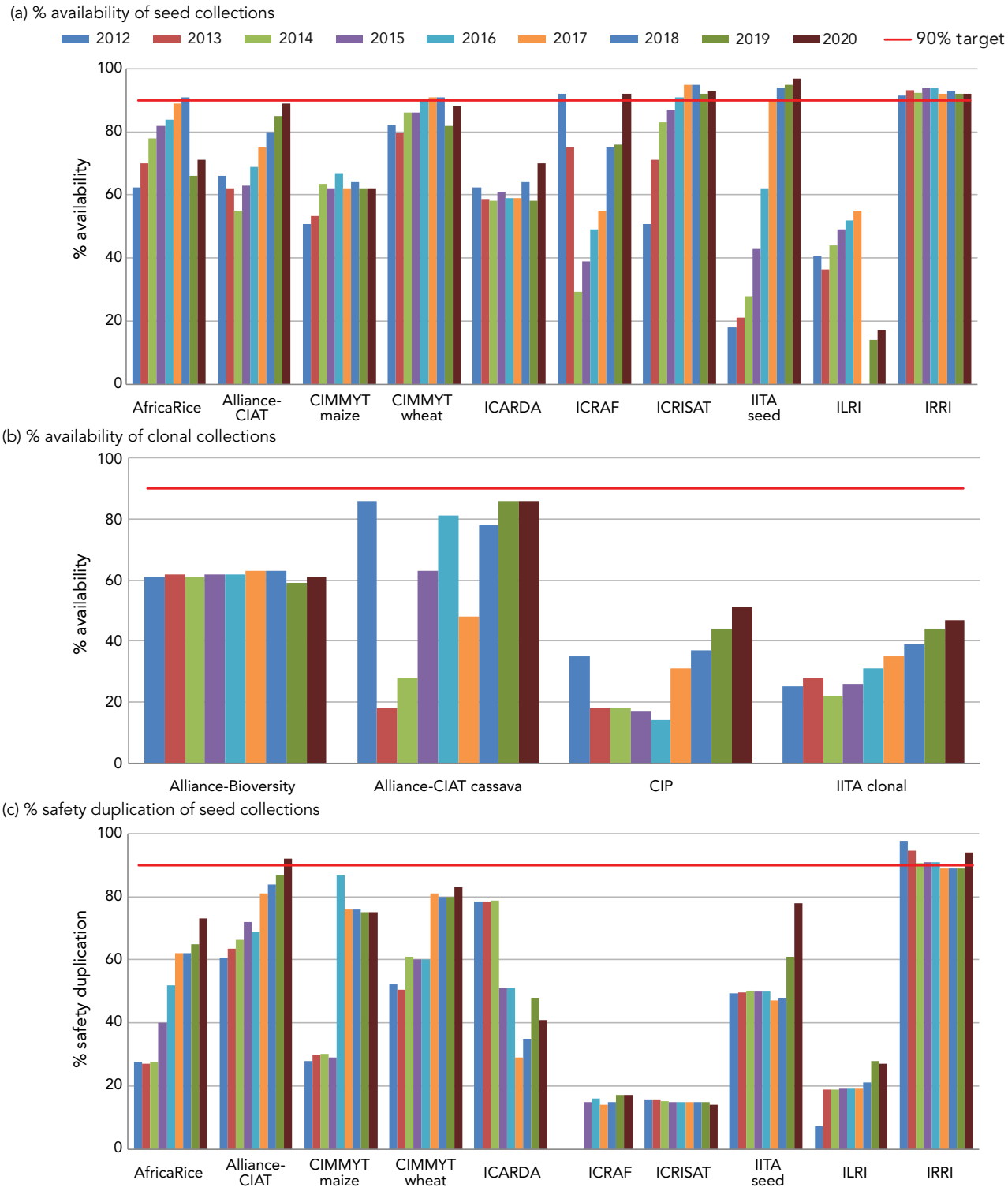


Figure 4. Trends in % availability and safety duplication of CGIAR collections

Table 4. Status of CGIAR genebanks with respect to performance targets in 2020

Center	% Availability 2020	% Increase from 2019	% Safety duplication 2020	% Increase from 2019	Comments
AfricaRice	71	8	73	12	Newly established in M'bé, the AfricaRice genebank is making progress towards performance targets, as well as dealing with a large number of materials that had been temporarily archived.
Alliance-Bioversity	61	3	65	0	For the first time, B genome accessions with endogenous Banana Streak Virus will be made available under certain conditions. The planned safety duplication in 2020 was prevented by lockdown restrictions.
Alliance-CIAT seed	89	7	92	6	Targets for availability and safety duplication will be met in 2021. Alliance-CIAT seed collections become eligible for a long-term partnership agreement (LPA) with the Crop Trust.
Alliance-CIAT cassava	86	0	16	-57	Safety duplication has been prevented by lockdown restrictions. However, there is a duplicate of the collection on site.
CIMMYT wheat	88	11	83	4	Deposits made in Svalbard Global Seed Vault (SGSV). Targets are potentially reachable in the next 2 years given the inventory of the collection is completed.
CIMMYT maize	62	0	75	0	Inventorying of the maize collection. The data and status of the collection against performance targets are likely to change in the next 2 years.
CIP	51	16	78	-12	Important milestones reached with more than half the collection now established as true-to-type and virus free and 73% of the potato collection in cryopreservation. Safety duplication is challenging under lockdown restrictions.
ICARDA	70	17	41	-13	Progress made to reach 90% availability. Safety duplication figures decreased due to recall of SGSV accessions.
ICRAF seed	92	35	17	0	Thresholds for availability have been revised which has allowed the seed collection to meet the availability target.
ICRISAT	93	1	14	-7	There continue to be obstacles to safety duplication at ICRISAT, which prevent the genebank from being eligible for an LPA.
IITA seed	97	2	78	25	IITA seed collections are likely to reach performance targets in 2021 and be eligible for an LPA.
IITA clonal	47	7	40	0	Gradual increase in bringing yam into tissue culture and cleaning them. Cassava and banana are closer to performance targets.
ILRI	17	21	28	0	Gradual increase in health testing and cleaning the collection.
IRRI	92	0	94	6	Some accessions have been assigned to a "partially curated" category, which does not require duplication, and therefore raises the % safety duplication.

CGIAR germplasm health units share some of their data and technologies in a capacity building visit from the national phytosanitary agency

This progress against the backdrop of the challenging working conditions is noteworthy. Of particular mention are the staff of CIP and Alliance-CIAT, who adapted processes and worked around the clock to prevent significant losses from the large tissue culture collections that they manage, despite experiencing the longest and most severe lockdowns. While accession losses were prevented in 2020, the level of safety duplication in these collections is now reduced, exposing them to greater risk in 2021.

According to reported data, seed collections managed by Alliance-CIAT and IITA will, for the first time, reach performance targets in 2021, which will render them eligible for long-term partnership agreements (LPA) with the Crop Trust. Collections managed by AfricaRice, Alliance-Bioversity, CIMMYT, ICRISAT and ICARDA can also reach eligibility in the next two years if planned inventory work, regeneration, disease-cleaning and safety duplications are successfully completed. The other genebanks making gradual progress towards performance targets are those which manage more challenging clonal crop collections, trees and forages.

Partnership with Chatham House on the future of genebanks

In collaboration with the UK think tank, Chatham House, a consultation with 35 thought leaders in the area of agriculture development and food systems helped to build a future vision of genebanks to inform the System Level Review of Genebank Costs and Operations.

The results of the consultation were directly relevant to One CGIAR deliberations, calling on CGIAR genebanks to play a more proactive, strategic and catalytic role in supporting the sustainable transformation of food, land and water systems through providing

CIP genebank manages seed collections of crop wild relatives as well as managing one of the largest tissue culture *ex situ* collections in the world. Photo: Michael Major/Crop Trust

IRRI genebank manager Venuprasad Ramaiah is presented a certificate by Norwegian Prime Minister, Erna Solberg, during the 2020 deposit of safety duplicates at the Svalbard Global Seed Vault

or sourcing crop genetic diversity on a wide scale, including staples, forages, underutilized crops, vegetables, roots, tubers, fruits and crop wild relatives and even non-food crops that are important for generating income and employment in smallholder agricultural systems. The mission of genebanks is to conserve the right resources and deliver them in

CGIAR genebanks in Sub-Saharan Africa consult with regional and national partners in West and Central Africa to determine how they might best provide more integrated support

ICRAF's work on seed dormancy breaking is key to successfully conserving diverse tree species in an *ex situ* collection. Photo: Shawn Landersz

the right way. The new CGIAR Genebank initiative should lay the foundations for a future vision when genebanks have cataloged all functional variants of all genes for all accessions in their care, allowing more precise use of diversity and a more meaningful estimation of the values of each accession to crop improvement, other uses and also their option value. In turn, this would lead to more strategic accession management, consolidation of operations or collections and automation of key operations.

GRIN-Global Community Edition

Under the Genebank Platform, several CGIAR genebanks have tested, adopted and customized GRIN-Global software for publishing accession information online. GRIN-Global was originally developed by the USDA National Plant Germplasm System (NPGS) in collaboration with the Crop Trust. Several other national genebanks have also adopted the software. CIMMYT is acting as a coordinator and is providing training, backstopping and a helpdesk to numerous countries as well as to CGIAR genebanks for GRIN-Global adoption.

In 2020, the CGIAR Data Management Community of Practice adapted GRIN-Global software to create "GRIN-Global Community Edition" (GG-CE), using a new open-source solution to address the gaps in functionality. GG-CE will facilitate inventory management in all collection types, including tissue culture and field, as well as use of mobile devices and barcoding and interoperability with other data systems such as Genesys and breeding data management solutions. Furthermore, in a move to prepare for One CGIAR reform, the Platform Management Team decided to adopt one database management system for CGIAR genebanks, agreeing to dedicate time and resources in 2021 to evaluate options and finalize which system to adopt.

Germplasm Health Units (GHUs)

In 2020, the GHUs health-tested 295,742 samples for approximately 400 seed-borne pests and pathogens using a total of 1,056,417 diagnostic assays (Table 5). Most (75%) of the tested samples were for conservation actions in genebanks, with the rest being for import or export of germplasm. Nearly 10% of

Crop Trust worked with UK Thinktank, Chatham House, to consult thought leaders on a future vision for the role of genebanks

IITA has completed an extension of the genebank to accommodate workflows and safety and health standards for the collections and cryobank including solar panels to improve sustainability

the samples were infected and eliminated. GHUs facilitated 1,415 germplasm and some non-plant exchanges with 123 countries. Together, the group continued to develop QMS, drafting 172 SOPs and mapping them to a shared GHU operational framework. GHUs at AfricaRice, ILRI, and ICRAF continued to be upgraded.

Use Module

Genesys (www.genesys-pgr.org)

Genesys, the online portal for accession data for genebanks worldwide, is part of the Plant Treaty's Global Information System (GLIS). By the end of 2020, the passport data of more than 4 million accessions were searchable from Genesys, including from CGIAR, USDA-NPGS, and the European Cooperative Programme for Plant Genetic Resources (ECPGR). New capabilities continue to be developed. In 2020, Genesys introduced "GRIN Taxonomy", linking 90% of the 4 million accessions in Genesys to correct and valid taxonomic names. This allows users to find accessions even if names are misspelled or taxonomy is outdated (e.g. *Solanum lycopersicum* vs *Lycopersicon esculentum*). Genesys may now also be customized by institutions to provide a searchable accession website, easily embedded into their websites.

Considering the quality of accession data, the passport data completeness index (PDCI) continues to increase in CGIAR genebanks (Table 6).[1] There is also increasing use of DOIs minted by the Plant Treaty Secretariat. There are currently more than a million accessions with DOIs in Genesys and 99% of accessions in CGIAR genebanks have DOIs. Some breeders have also adopted DOIs for their materials (e.g. ICRISAT). Such pivotal developments will facilitate the documentation of the use of genebank or other materials in research and variety development.

[1]The passport data completeness index (PDCI) uses the presence or absence of data points in the documentation of a genebank accession, taking into account the presence or value of other data points. See Hintum et al. 2011.

Table 5. Germplasm samples processed for conservation and distribution by GHUs in 2020

Center	Genebanks		AFS CRPs		Total	
	Samples analyzed	Diagnostic reactions	Samples analyzed	Diagnostic reactions	Samples analyzed	Diagnostic reactions
AfricaRice	105,688	134,396	742	5,572	106,430	139,968
Alliance-Bioversity	420	1,162	-	-	420	1,162
Alliance-CIAT	4,882	36,558	1,554	15,508	6,436	52,066
CIMMYT	1,355	19,106	4,814	86,193	6,169	105,299
CIP	4,354	29,755	88	528	4,442	30,283
ICARDA	21,759	273,654	25,019	303,441	46,778	577,095
ICRAF	271	170	3	6	274	176
ICRISAT	8,249	16,498	3,508	7,038	11,757	23,536
IITA	92,837	93,832	12,834	9,215	105,671	103,047
ILRI	7,375	23,785	-	-	7,375	23,785
IRRI	-	-	-	-	-	-
Total	**247,190**	**628,916**	**48,562**	**427,501**	**295,752**	**1,056,417**

Heterogeneity within accessions

Genotypic data derived from Diversity Arrays Technology (DArTseq) from 15,000 samples of 865 accessions from seven genebanks has generated 526,000 SNPs and provided a striking picture of the distribution of diversity within collections. Unsurprisingly outcrossing species (e.g. pearl millet, lablab and pigeon pea) show relatively high levels of within-accession diversity (>50% total variance between plants vs between accessions), while rice and wheat show relatively little (<25%). However, some collections, such as wild potato, show less diversity than expected, suggesting that some purification of accessions has occurred through collecting, germplasm distribution or regeneration over time. The study is helping to guide improvements in collecting and genebank processes (e.g. regeneration, sampling) for specific crops (Figures 5 and 6).

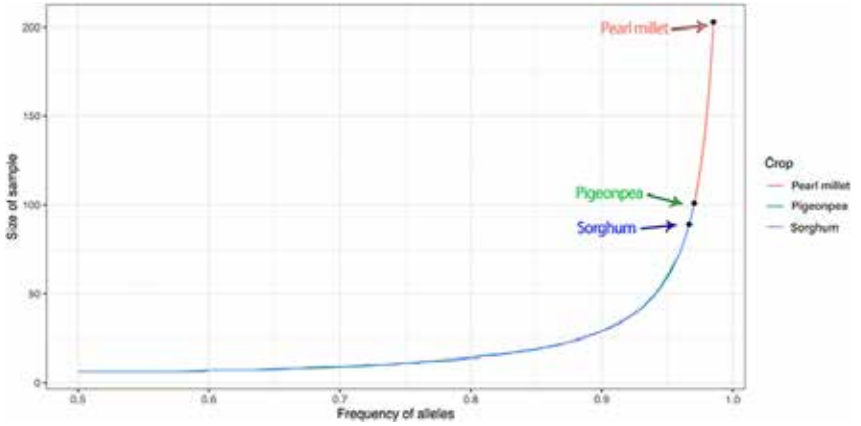


Figure 5. Sample sizes needed for regeneration to reach 95% probability of capturing 95% of alleles, showing exponential increase in sample size to capture rare alleles in different crops. Source: Allan et al. 2020

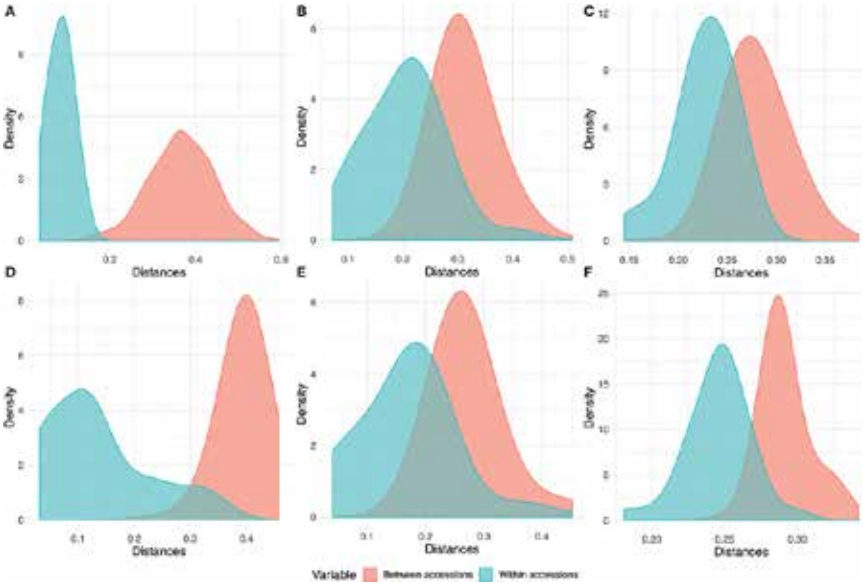
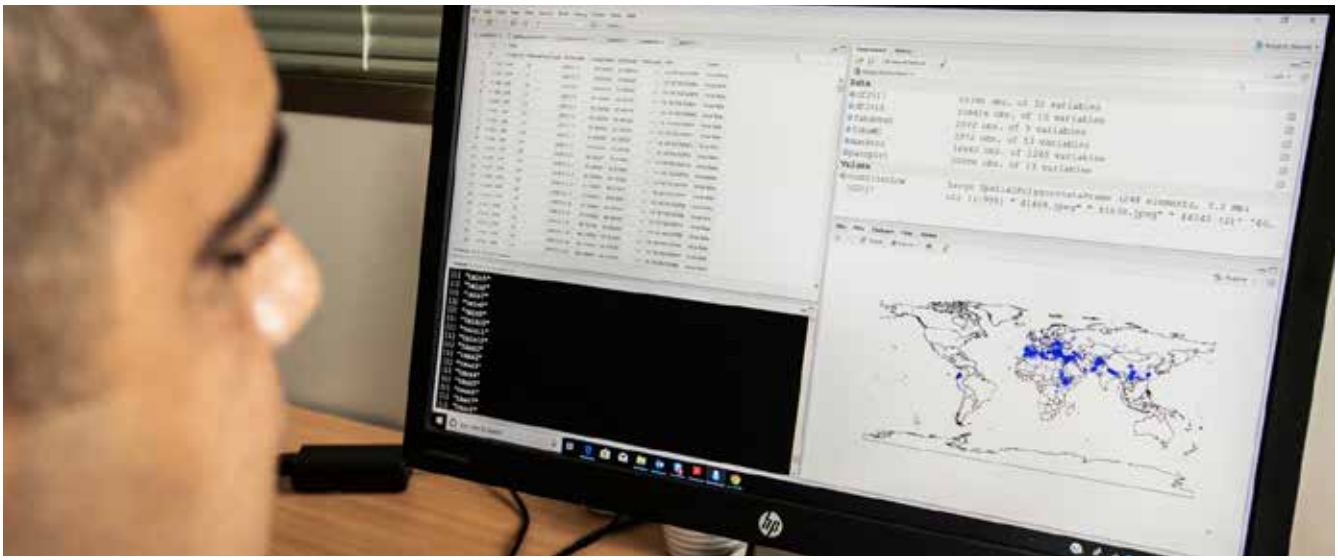


Figure 6. Density distribution of within- and between-accession distances based on phenotypic data (A to C) versus genotypic data estimated from DArTseq-SNPs (D to F) for sorghum, pigeonpea and pearl millet, showing the lower differentiation of accessions in cross-pollinated crops. Source: Allan et al. 2020

Table 6. CGIAR germplasm data publicly available in 2020

Center	Number of accessions uploaded	% of DOIs	Passport Data Completeness Index (PDCI)			
			2017	2018	2019	2020
AfricaRice	21,300	100%	5.60	5.89	7.67	8.07
Alliance-Bioversity	1,621	100%	5.57	5.94	6.22	6.25
Alliance-CIAT	66,599	100%	6.70	6.94	6.80	6.98
CIMMYT	178,748	100%	5.65	6.22	7.11	7.26
CIP	18,066	100%	5.61	7.53	7.39	7.41
ICARDA	156,929	100%	6.76	6.65	5.84	6.79
ICRAF	15,156	100%	6.69	6.68	6.33	6.77
ICRISAT	128,155	99%	6.89	6.95	7.27	7.27
IITA	35,617	100%	4.69	5.12	4.64	4.71
ILRI	18,641	100%	6.88	6.80	5.71	5.71
IRRI	132,124	96%	5.45	5.09	6.35	6.53
All	**772,956**	**99%**	**6.04**	**6.28**	**6.48**	**6.70**

Source: Genesys (https://www.genesys-pgr.org/)



Identifying adaptive traits through analysis of geographical origin of accessions is a key way of developing subsets through Focussed Identification of Germplasm Strategy (FIGS), a method developed at ICARDA and adopted by other CGIAR genebanks. Photo: Michael Major/Crop Trust

Subsetting

All genebanks are developing and characterizing user-focused subsets of genebank accessions to help facilitate the selection of material for users. A major push on publishing trait and subset data has resulted in 135 subsets and 433 datasets now being available, with the aim of encouraging breeders and other users to explore the diversity in the collections. New subsets developed and made available online by AfricaRice, ICRISAT, CIP, and ICRAF are listed in Table 7.

Policy Module

Coordinating CGIAR engagement in international policy negotiations

The Policy Module of the Genebank Platform, led by Alliance-Bioversity, supports CGIAR in contributing to international genetic resources policy fora. In 2020, it coordinated CGIAR's engagement in the development of the Post-2020 Global Biodiversity Framework of the Convention on Biological Diversity (CBD). The Policy Module also contributed to Plant Treaty meetings on the development of decision-making tools for the implementation of farmers rights under Article 9.

Table 7. New subsets made publicly available from genebanks in 2020

Genebank	Subset title
AfricaRice	The top most distributed *Oryza glaberrima* landraces
	The top most distributed *Oryza sativa* germplasm
	Oryza glaberrima germplasm tolerant to abiotic stresses
	Rice yellow mottle virus resistant *Oryza glaberrima* germplasm
	The top most distributed improved interspecific germplasm
	African gall midge resistant *Oryza glaberrima* germplasm
	Bacterial blight resistant *Oryza glaberrima* germplasm
ICRISAT	Kodo millet diversity subset
	Proso millet diversity representative subset
	Sorghum mid rib
	Sorghum high biomass
	Sorghum multi trait mini core
CIP	Orange flesh sweetpotato (OFSP)
	Purple fleshed sweetpotato (PFSP)
ICRAF	Marula provenance evaluation
	Big Marula fruits

Source: Genesys (https://www.genesys-pgr.org/subsets)

All genebank staff helped with the harvest of accessions during lockdown at ICRISAT

ICARDA successful regenerated more than 27,000 accessions in 2020, including safety duplicates returned from the Svalbard Global Seed Vault

Developing guidelines and tools to promote compliance of CGIAR with genetic resource policies and laws

In 2020, the Policy Module supported CGIAR Centers in complying with their policy and legal obligations through a range of measures including the development of guidelines and decision-making tools for improving accession management and enhancing operations under the frameworks of the Plant Treaty and the CBD.[2] Several policy statements were also developed to clearly communicate CGIAR's deployment of genetic engineering, genome editing, and the generation and use of genomic sequence information.[3] The Policy Module worked closely with the System Office in reviewing Centers' compliance with the CGIAR Intellectual Assets Principles, with a particular focus on intellectual assets derived from genetic resources.

Strengthening Centers' capacity to comply with PGRFA policies and laws

The Policy Module maintains a Policy Helpdesk[4] for CGIAR scientists and, in 2020, worked with the UK's Open University to develop a 24-hour long online training course on genetic resources policy targeted to students and scientists who work with genetic resources in breeding, conservation or exchange. The course, which is expected to be ready by mid-2021, is one of a number of guidelines and tools that the Policy Module has developed to support genetic resources conservation and use under the frameworks of the Plant Treaty and the CBD.

[2]See: Guidance Note for CGIAR Genebanks on Improving Accession Management; Guide for CGIAR Centers' operations under the Plant Treaty framework; Decision-making tool for mainstreaming compliance with access and benefit-sharing laws in CGIAR R&D project planning. Note: These documents are currently under review and will be made available in CGSpace in 2021.

[3]See: CGIAR Questions and Answers on Genetic Engineering; CGIAR Questions and Answers on Genome Editing; CGIAR Statement on Digital Sequence Information. More info is on the CGIAR website.

[4]Requests for assistance can be sent to: GRPolicy-Helpdesk@groups.cgiar.org

1.2.2.b. Relevance to COVID-19 by flagship

The COVID-19 pandemic required a major reassignment of genebank and GHU staff to shift and remote working. The focus of all genebanks, during lockdown, aside from keeping staff safe, was on sustaining sufficient staff in the laboratories, screenhouses and fields to carry out critical operations to avoid the loss of accessions. These included monitoring cold rooms, subculturing *in vitro* accessions and processing seed from harvest to cold room. In a small number of cases, harvests were lost. Genebanks and GHUs continued to respond to requests for germplasm and phytosanitary testing as a priority. Germplasm distributions declined by around 50% compared to a normal year. However, more than 90% of requests received were fulfilled.

Large tissue culture collections (>5000 accessions) were the most vulnerable to lockdown measures, since they require continuous monitoring and subculturing by trained staff working in relatively small spaces. Procedures were modified to ensure all accessions were given necessary attention, which included reducing numbers of samples per accession, deploying staff from other teams to help and running shifts over the weekend. Inevitably, some samples were lost but replaced by safety duplicates. However, given the reduced staff capacity to generate new safety duplicates, the status of the tissue culture collections in Latin America is becoming more precarious over time under lockdown conditions.

More positively, although managers reported that some operations were reduced to as little as 36% of the normal rate, progress was made towards performance targets in 2020. Staff working remotely meant more time was dedicated to working on and cleaning legacy data and developing software and apps for GRIN-Global CE. The Crop Trust coordinated with the CGIAR System Office and Centers' risk specialists to undertake a genebank risk assessment in

Brigitte Maass during the ICRISAT genebank review, which took place a few days before lockdown was imposed in India. Photo: Charlotte Lusty/Crop Trust

The Rice Biodiversity Center for Africa (RBCA) was officially inaugurated on 21 February 2020 at the Africa Rice Center Research Station in M'bé near Bouaké, Côte d'Ivoire. Photo: AfricaRice

June 2020 with the aim of ensuring that measures were in place to facilitate remote working, including strengthening automated alarm and temperature control systems in cold rooms and drying rooms, and installing remote cameras, irrigation systems and extra laminar flow cabinets. Learning has been incorporated into revised genebank risk management strategies.

Germplasm collecting and research work on seed quality management, cryopreservation, gap analysis and subsetting were set back. Few of the physical meetings planned for 2020 took place, but more attention was paid to developing online training tools, such as the Policy Module's Open University training course on plant genetic resources policy. The genebank technical reviews continued successfully in a virtual format and the Annual Genebank Meeting, System Level Review of Genebank Costs and Operations and Chatham House Dialogue were able to extend invitations to more staff, partners and thought leaders as a result of their virtual format.

Reports were made periodically during the year by the Crop Trust and CGIAR to the System Office, Plant Treaty Secretariat and the Crop Trust Executive Board on the status of operations in the CGIAR genebanks during the pandemic. The Plant Treaty Secretariat, the Crop Trust and FAO hosted a virtual meeting on the "Impact of the COVID-19 pandemic on the conservation, use and exchange of plant genetic diversity" in September 2020 with the sponsorship of the Kingdom of Morocco. Impacts on national, regional and local programs and on farmers' seed security were discussed. CIP presented on the effects of the pandemic on behalf of the CGIAR genebanks.

Peter Wenzl, genebank manager at Alliance-CIAT, has been overseeing the development of the new Future Seeds genebank facility due to be ready for occupation in 2021

1.2.3 Variance from Planned Program

Genebank Platform activities follow a relatively fixed program of work focused on the essential operations of the genebanks and GHUs. The variance due to COVID-19 has been described in detail above. As a result of One CGIAR developments and other considerations, the Genebank Platform Management Team decided to implement a workplan in 2021 towards the adoption of one data management system for all CGIAR genebanks. This is more ambitious than the original proposal, which aimed to support the adoption of GRIN-Global in only six Centers.

Germplasm distribution was lower in 2020 but more than 90% of requests were addressed by CGIAR genebanks. Alliance-Bioversity distributed nearly 600 samples in their unique distribution pods, which is an increase on 2019 distribution. Photo: Nelissa Jamora/Crop Trust

1.2.4 Altmetric and Publication highlights

The Genebank Platform website (www.genebanks.org) provides links to research papers, policy briefs, conservation protocols, training materials, and submissions to international policy fora in conformity with CGIAR Open Access and Data Management Policy. In 2020, the genebanks reported a total of 151 publications by genebank staff in journals, conference proceedings, books, and book chapters, covering a wide range of topics. Out of 111 peer-reviewed journal articles, 80% are publicly available in open-access publications and 84% are published in ISI journals (Table 8).

A number of significant publications came out in 2020. A diversity analysis of 80,000 wheat accessions from CIMMYT and ICARDA genebanks based on DArTseq genotyping, was published in *Nature Communications*. The study is ground-breaking in identifying specific genes, chromosome regions and germplasm representing diversity currently absent from breeding programs. *Frontiers in Plant Sciences* published the results of a small study based on DArTseq genotyping of a subset of sorghum, pearl millet, and pigeonpea landraces conserved at ICRISAT genebank to determine patterns of genetic diversity within and among accessions. *Nature Scientific Reports* published a paper on optimized sampling methods of rice accessions according to inter-accession genetic diversity studies based on DArTseq genotyping.

A novel study on landrace gap analysis was published in March 2020 in *Biodiversity Research*. It provides a framework for modeling and mapping landrace distribution and highlighting where there are gaps in *ex situ* collections, using common bean as a case study. The approach can be used to assess the coverage of the cultivated genepool and to highlight geographic areas where further collecting should be prioritized.

Curating the herbarium collection at CIP. Photo: Michael Major/Crop Trust

Table 8. Number of peer-reviewed publications in 2020

	Number	Percent
Peer-reviewed publications	111	100%
Open Access	89	80%
ISI	93	84%

In 2020, an open-access article published in the journal *Plants* analyzed factors affecting the CGIAR genebanks' rates of acquisition and distribution of PGRFA from 1980 to 2020, with a particular focus on comparing Centers' rates of acquisition and distribution over the last 10 years with the previous decade. It was led by the Genebank Platform Policy Module and involved genebank managers and staff from the Crop Trust. The findings are relevant to ongoing efforts by the international community to revise and develop new access and benefit sharing rules for both genetic materials, and more recently, digital sequence information.

The October 2020 issue of *Food Security* journal featured a special section on genebanks. Ten papers from the Genebank Impacts Community of Practice were published to demonstrate the different values accruing from conserving and supplying plant genetic resources in genebanks to researchers, plant breeders, and farmers. The special section starts with an introductory article by Melinda Smale (Michigan State University) and Nelissa Jamora (Crop Trust) on *Valuing genebanks*.

1.3 Cross-cutting Dimensions

1.3.1 Capacity Development

CGIAR genebanks and GHUs carry out services to CRPs and national partners to conserve, test, clean and distribute germplasm. They also serve as knowledge hubs, responding as requested with data or advice on phytosanitary issues, taxonomy, cryopreservation, genebank operation, etc. and they act as hosts for safety duplicated materials for NARS partners. In 2020, individual genebanks reported 83 different genebank services were provided to national partners in 23 countries. In addition, the Policy Module provided a helpdesk on genetic resources policy issues and CIMMYT a helpdesk to assist in the evaluation, adoption and use of GRIN-Global accession management software.

In 2020, individual genebanks reported fewer capacity building events than normal due to COVID-19 restrictions, but still more than 160 events took place across the Platform. The activities involved more than 1,100 participants (39% female) from 25 countries (Tables 9, 10 and Annex 2), including 119 genebank tours to promote the importance of crop diversity and the work of CGIAR.

Two webinars were organized by the Genebank Data Management Community of Practice in 2020 to facilitate the development and adoption of GRIN-Global for accession management in genebanks. Representatives from the Crop Trust, CGIAR and national genebanks participated in two separate "Live Discussions" hosted by the Global Landscapes Forum (GLF). GLF is the world's largest knowledge-led platform on integrated land use, dedicated to achieving the SDGs and Paris Climate Agreement. Participants discussed the role of genebanks in times of global crisis and how the pandemic affects all parts of society and the economy, including agriculture and food systems.

Table 9. Platform and Module level capacity building events in 2020

Event	Date	Host organization	Location
GLF Live: What is the role of genebanks in times of pandemic?	13 May	Global Landscapes Forum Events (GLF), Crop Trust	Virtual
GRIN-Global Wizards webinar	12 Jun	CIMMYT, CIP	Virtual
Genebank Impacts Bootcamp workshop	13-19 Aug	Crop Trust	Virtual
Annual Genebanks Meeting (AGM)	20–29 Oct	Crop Trust	Virtual
GLF Live: Biodiversity for Resilience	28 Oct	Global Landscapes Forum Events (GLF), Crop Trust	Virtual
GHU Phytosanitary Awareness Week	9–13 Nov	IITA, GHUs	Virtual
GRIN-Global Admin Tool webinar	24 Nov–10 Dec	Genebank Platform, USDA National Plant Germplasm System (NPGS)	Virtual
QMS Intensive, ICARDA	22–28 Jan	Crop Trust, Genebank Platform	Hyderabad, India
QMS Intensive, ICRISAT	12–18 Feb	Crop Trust, Genebank Platform	Rabat, Morocco
Genebank Review, ICRISAT	3–5 Mar	Crop Trust, Genebank Platform	Hyderabad, India
Genebank Review, Alliance-Bioversity	3–5 Mar	Crop Trust, Genebank Platform	Leuven, Belgium
Genebank Review, AfricaRice	30 Mar–3 Apr	Crop Trust, Genebank Platform	Virtual
Genebank Review, ICRAF	27–30 Apr	Crop Trust, Genebank Platform	Virtual

Table 10. Participants in capacity development activities in 2020

Event category	Number of events	Number of participants
Genebank visits and tours	119	769
Genebank-organized training/workshop	17	210
Genebank staff as resource person in a capacity development event	12	110
Visit from partners for research/scientific work	3	21
Hosting a scholar/student in the genebank for educational purpose	12	16
Total	**163**	**1,126**

All GHUs organized or took part in events to mark the UN's International Year of Plant Health and, in November 2020, a global webinar series took place to promote the role of GHUs in preventing the transboundary movement of pests and diseases. Several webinars and meetings were conducted to discuss future scenarios, needs for germplasm health and bio-risk mitigation, and global efforts to contain the spread of invasive transboundary pests, as well as best practices in GHUs and their engagement and collaboration with national and international plant health organizations.

Two QMS Intensives were conducted in 2020 at ICRISAT, Hyderabad in January and at ICARDA, Rabat in February. At least 30 genebank staff attended to work on QMS issues, including addressing review recommendations, drafting SOPs and preparing for audits. The Intensives allow for one-on-one instruction and have resulted in a QMS that is tailored to suit specific genebank and crop needs.

Through their partnership with the Crop Trust, CGIAR genebanks have also provided technical support to national genebanks in Sub-Saharan Africa under the National Seeds Collections for Climate-Resilient Agriculture in Africa (Seeds4Resilience - S4R) Project, funded by the Federal Government of Germany through the German Development Bank (KfW). The S4R Project is working with the national genebanks of Nigeria, Zambia, Kenya, Ethiopia, and Ghana. IITA played an expert role in a technical genebank review, as well as providing backstopping for the five national genebanks. CIP and ICARDA shared their expertise with national partners through virtual meetings hosted by the S4R Project, including through live or recorded demonstration of operations.

As part of the Seeds4Resilience Project, CGIAR genebanks provide technical support to national genebanks like Nigeria's National Centre for Genetic Resources and Biotechnology. Photo: Nora Castañeda-Âlvarez /Crop Trust

Introducing new processes in CIMMYT tailored to the extraordinary within-accession diversity of the maize collection Photo: Shawn Landersz

A tropical forage accession in the field collection managed by ILRI at Zwai in Ethiopia. Photo: Shawn Landersz

As part of the Genebank Impacts Fellowship, farmers in Côte d'Ivoire are being interviewed on a valuation study about rice genetic resources from AfricaRice genebank. Photo: Rachidi Aboudou/AfricaRice

Effectiveness and Efficiency

2.1 Management and governance

There have been no changes to governance arrangements.

2.2 Partnerships

2.2.1. Highlights of External Partnerships

The primary partners of CGIAR genebanks and GHUs are the wide range of users from numerous countries who requested germplasm, advice, and information in 2020 (Table 11). The exchange of germplasm takes place within a policy framework that demands close partnership with the Plant Treaty, the Commission on Genetic Resources for Food and Agriculture (CGRFA) and the International Plant Protection Convention (IPPC). The Svalbard Global Seed Vault is an essential partner in long-term conservation, as well as in communicating to the wider world the importance of crop diversity and the organizations that conserve it. CGIAR genebanks provide more than germplasm to users, however. Individual genebanks provide a range of services and support to national partners, including information, data, training, as well as hosting safety duplicates. The services rendered involved working with 83 countries.

2.2.2. Cross-CGIAR Partnerships

The most significant cross-CGIAR exchange occurring within the framework of the Genebank Platform concerns the movement of germplasm and associated data: the acquisition of materials from CGIAR breeding programs by genebanks, the distribution of germplasm from genebanks to research and breeding programs, and the phytosanitary testing of materials by GHUs. In 2020, 2,150 samples were acquired from CGIAR breeding programs and 11,007 samples were sent to breeding programs. In addition, many exchanges occurred between genebanks and Platforms or CRPs, some of which are captured in Table 12.

2.3 Intellectual Assets

All CGIAR genebanks have agreements with the Plant Treaty, placing their germplasm collections under its Multilateral System of Access and Benefit Sharing. The collections, and the germplasm contained within them, remain publicly available and no patents or plant variety protection rights are sought on the germplasm. In 2020, 95% of samples externally distributed by the Centers were transferred under Standard Material Transfer Agreements (SMTA). The remaining 5% of transfers were sent by ICRAF to farmers, for which an SMTA is not required, many as part of projects on landscape restoration and regreening in Africa.

2.4 Monitoring, Evaluation, Impact Assessment and Learning (MELIA)

The outputs from the Genebank Platform are monitored through the Crop Trust online reporting tool (ORT) using agreed performance targets (Table 13).

Technical and financial reviews

Genebanks and GHUs have documented more than 300 Standard Operating Procedures (SOPs) as part of their quality management systems (QMS), 146 SOPs

Table 11. Key external partnerships of the Genebank Platform in 2020

Module	Description	Name of partner	Main area of partnership
Conservation	Ultimate safety duplication of CGIAR germplasm	Svalbard Global Seed Vault	Risk management
	Research collaboration, partnership for germplasm distribution, safeguarding of genetic resources, recipient of capacity building and other genebank services	National genebanks Global Crop Diversity Trust	Capacity development and risk management
	Collaboration in the delivery of the Global Plan of Action	Commission on Genetic Resources for Food and Agriculture (CGRFA)	International policy
	Collaboration in safe exchange of germplasm	International Plant Protection Convention (IPPC) and national plant protection agencies	Phytosanitary and international policy
	Provision of germplasm, clean planting materials, information and advice	83 countries	Delivery
	Training and support for accession data management using GRIN-Global	USDA National Plant Germplasm System (NPGS)	Capacity development
Use	Global information system (GLIS) on plant genetic resources for food and agriculture	International Treaty on Plant Genetic Resources for Food and Agriculture (Plant Treaty)	Delivery and policy
Policy	International PGRFA policy development and compliance, capacity building for policy implementation at national level	Plant Treaty and Convention on Biological Diversity (CBD) Secretariats	International policy

Table 12. Cross-CGIAR Collaborations (beyond the exchange of germplasm) in 2020

Collaborating CRPs, Platforms, Centers	Brief description of the collaboration
Forests, Trees & Agroforestry	Genebank supported FTA and bilateral projects on restoration/regreening (ICRAF)
Grain Legumes and Dryland Cereals	Work with the Bean Program and NIAB on a BBSRC-funded project focusing on the characterization of natural interspecific bean hybrids as a potential starting point for genetic-improvement for disease resistance and other traits. (Alliance-CIAT)
Livestock	Progress was made in employing molecular technologies to reveal and describe more of the diversity held in our forage collections. A core collection was identified which could enhance the use of the buffel grass genetic resources held in the ILRI genebank. Key outcomes include several journal publications on the Genome-Wide Association Study between agronomic performance and nutritional quality traits with regions in the Napier grass genome and on genotyping-by-sequencing and genetic diversity analysis of our buffel grass collection. (ILRI)
Maize	Evaluation of maize landraces accessions for heat tolerance (CIMMYT)
Rice	Evaluation of minicore set of *O. glaberrima* developed by the genebank for cold, heat and salinity tolerance, yield potential, iron toxicity and other physical and chemical grain characteristics (AfricaRice)
Roots, Tubers and Bananas	Analysis of yam diversity hotspots in the Republic of Benin and the collection of DNA samples from selected hotspots. The partnership has developed a Golden Egg proposal to highlight the need for continuation of *in situ* diversity studies, hotspot identification and monitoring and links to *ex situ* conservation and seed systems. (IITA)
	Collaboration with Grupo Yannapi to work on monitoring diversity of potato in Peru both *in situ* and *ex situ*. Over 400 tubers were received from farmers, photographed, and tuber skin was used to extract DNA. SNP genotyping was employed to compare these potatoes with the ex situ collection at CIP. Genotyping analysis demonstrated that 30 accessions were unique. Of these, 25 have been successfully added to the CIP genebank with 5 still in the process of introduction. (CIP)
	Genomics and bioinformatics tools were put in place to allow gene discovery and diversity studies of the material conserved in the collection managed by Alliance-Bioversity. The RTB Breeding CoP was instrumental in providing crops and traits ontologies as well as the linkage to breeding database (BRAPI). (Alliance-Bioversity)
	Work with the Cassava Program to start shipping the cassava core collection to Laos and Vietnam. The collection will be screened to identify materials resistant to cassava mosaic disease. (Alliance-CIAT)
Wheat	Evaluation of subsets and prebreeding activities (ICARDA)
EiB	A SNP chip was previously customized with help from EiB. In 2020, ~4000 samples were genotyped with assistance from EiB. (IRRI)
	External review by Module 5 EiB on data management for breeding and genetic resources (ICARDA)
	Participated in meetings with EiB to discuss AfricaRice genebank activities, priority research areas to link genebank collection with product development, and seek ways that EiB can support AfricaRice genebank's efforts in trait donor identification and pre-breeding (AfricaRice)
	Participation in the EiB Platform Steering Committee. A workshop on fish, livestock, forages and forestry workshop is planned for 2021. (ILRI)
	Close collaboration with the EBS software developers to incorporate genebank processes in the program. (CIMMYT)
	Participation in EiB activities and CtEh investments (IITA)
Big Data	Discussions regarding the interface of PGR and data/DOI/GLIS. (Alliance-CIAT)

have been audited and were verified through external technical reviews.

SOPs for key operations (regeneration, multiplication and characterization, seed drying and storage, viability testing, *in vitro* management, field conservation, safety duplication and germplasm distribution) formed the basis of the external reviews. All SOPs were reviewed for standard elements concerning equipment and infrastructure, risk management, genetic integrity, germplasm lot identity, germplasm quality management, data management and efficiency. Reviewers assessed whether written procedures matched the actual practices of staff on the ground and were compliant with relevant standards. Detailed observations and recommendations were provided in written reports (Figure 7). A key part of the review process involved validating accession data in live databases with what is reported annually and with tangible evidence (e.g. packets in storage).

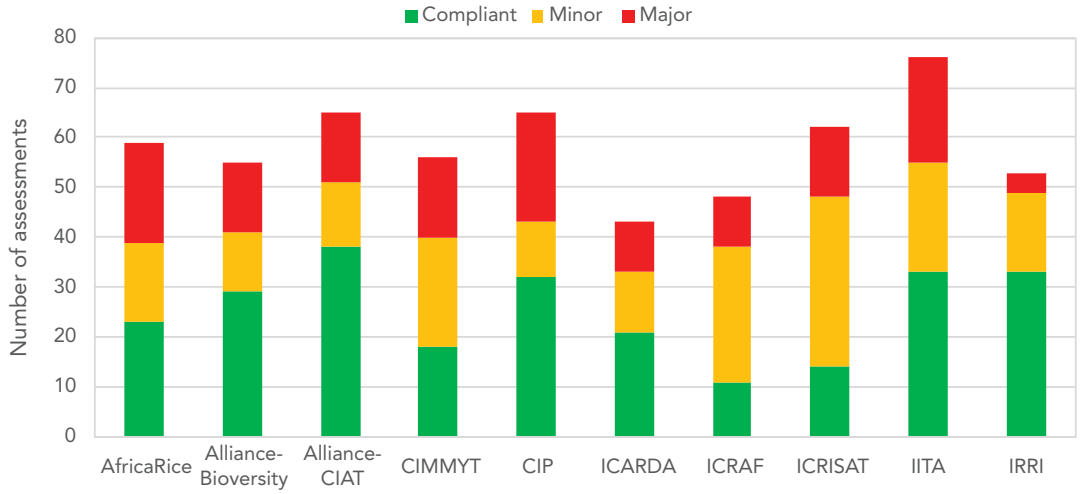


Figure 7. Compliancy and observations made by external reviewers of CGIAR genebanks against standards for five key operations.

Table 13. Monitoring, Evaluation, Learning and Impact Assessment (MELIA) in 2020

Studies/learning exercises planned for this year	Status	Type of study or activity	Comments	Links to evidence
External technical reviews and validation of QMS	Complete	Program evaluation	Four technical reviews of CGIAR genebanks were completed in 2020, completing this phase of technical review. The results fed into the System Level Review of Genebank Costs and Operations (GCO). Key actions to address recommendations were also developed into funded workplans for 2021.	https://bit.ly/2ROI3Jg
Costing reviews of CGIAR genebanks	Complete	Program evaluation	The final three costing reviews of CGIAR genebanks were completed in 2020. The results of all 11 costing reviews fed into the GCO review and will be used as a basis for the Crop Trust Long-term partnership agreements (LPA).	https://bit.ly/2QSUOlv
System level review of genebank costs and operations (GCO)	Complete	System level evaluation	A panel of eight experts and representatives from CGIAR System, Crop Trust and Plant Treaty Secretariat were convened. Six background papers were prepared. A wider consultation was held in partnership with Chatham House. A report with recommendations was shared with CGIAR and Crop Trust.	https://bit.ly/3dFoziN
Document audits of Standard Operating Procedures (SOPs)	Ongoing	Audit	A total of 345 Standard Operating Procedures (SOPs) have been mapped and 316 SOPs drafted by genebanks and germplash health units. To date 146 SOPs have been subject to document audits.	https://bit.ly/32FrnGp
Genebank Impacts Fellowship	Ongoing	Other MELIA activity	The impact of the CGIAR genebanks was documented as part of the Genebank Impacts Fellowship program launched in 2018. A series of case studies prepared by the first cohort of fellows was published in October 2020, in a special issue of *Food Security*, titled *Genebanks and Food Security in a Changing Agriculture*. Five new fellows were recruited in 2020 to work on new research topics.	https://bit.ly/3xdYnDT

A total of 137 findings were reported. Recent achievements are evident; however, genebank managers face the challenge that the collections they manage are old and have grown over time, frequently without adequate documentation or strategic direction. The status of the collections is inevitably influenced by their legacy of documentation, decisions and procedures. Table 14 summarizes typical observations.

In parallel with the technical reviews, a series of costing studies has also been completed to inform the Crop Trust and CGIAR of the use of funding for routine operations. Preliminary benchmarking with equivalent genebanks indicates that CGIAR genebanks, especially those managing larger collections compare favorably in terms of costs per accession.

In September, a panel was convened for a System Level Review of Genebanks' Costs and Operations (GCO review). Working with the results of both technical and financial reviews the panel was able to make substantive recommendations for the consideration of CGIAR and the Crop Trust. Of particular significance, were recommendations to structure the genebanks at a system level to secure long-term conservation-related operations in perpetuity, as well as activities to ensure CGIAR remains or becomes a leader in seed longevity research, cryopreservation, genotyping-for-management and genebank automation technologies. GCO recommendations also support CGIAR's exploration of options to consolidate conservation activities and collections and enable the genebanks to play a more catalytic role in meeting demand for germplasm from a wide range of users and potential future users worldwide.

A series of impact case studies was published in 2020 in a special issue of the journal *Food Security*, entitled *Genebanks and Food Security in a Changing Agriculture* which resulted from an initiative to study some of the diverse impacts of CGIAR genebanks through a fellowship scheme overseen by the Crop Trust and Michigan State University. Five new fellows from Cameroon, Côte d'Ivoire, the Philippines, USA, and Germany were recruited in August 2020 for a further phase. They are working on research topics that will highlight not only the value and use of crop diversity managed by genebanks but also a range of genebank functions.

2.5 Efficiency

A costing study carried out by the Crop Trust has provided data on the rate of operation and use of base funding for essential operations. The study illustrated that the CGIAR genebanks are currently carrying out a higher level of operation but generally at a lower per accession cost compared to benchmark genebanks (Figure 8). The ambition to reach performance targets is driving a higher rate of regeneration in CGIAR genebanks at present. This rate should fall

Table 14. Summary of some shared or typical recommendations from 10 genebank reviews

Thematic area	Common recommendations
Optimize procedures and operations	Optimize viability monitoring load (reduce seed lots), improve regeneration sites/success/process, dormancy research, improve identity verification process, tissue culture protocols, storage containers, management of most original samples
Data management	Management of, manipulation and access to key data for curation, improve recording of/interpretation of data, data gathering, barcoding, validation and software/database development
Acquisition policy and collection composition	Acquisition policy especially relating to breeders' materials, collection composition, rationalization
Capacity building and personnel	Training in specialist areas, teamwork, clarity of responsibility/accountability, staff retention issues, delegation
Improve collection status	Status of parts of collection, their availability and safety duplication (esp. wild species, neglected seed lots, difficult crops, trees)
Risk management	Alarm systems, evacuation plans and exits, risk and disaster plans, dealing with liquid nitrogen.
Strategy and policy	Use of SMTA, strategic use of resources, recovery of costs, alignment with partner genebanks
Quality management system	Improve clarity and details in SOPs, question suitability of ISO
Data quality	Improve passport data from legacy data, provide more characterization data
Use of germplasm and collaboration	Analyze/follow up with users, proactive distribution, strategic partnership
Germplasm health	Reduce complexity of, improve or review GHU processes
Infrastructure & equipment	Repairs, electricity, gradient of cleanliness in *in vitro* labs
Visibility	Online experience in search for genebank accessions, website visibility

as performance targets are met and rates of health testing, viability testing and processing that occur as a result of regeneration likewise should reduce. IRRI provides an illustration of a genebank sustaining performance targets with a low regeneration rate but a high viability monitoring rate. Given that regeneration is one of the most costly genebank operations, this is a model to aim for in achieving greater cost-efficiency, at least in seed genebanks. The costing study results are providing numerous insights into genebank costs and operations across CGIAR and will be used to help design further work on seed quality management and cryopreservation in the new initiative. The Genebank Platform continues to pursue efficiencies on several levels through multiple mechanisms (Table 15).

2.6 Management of Risks to your Platform

Programmatic risks: The Crop Diversity Endowment Fund managed by the Crop Trust currently stands at USD 365.5 million, which is short of its first target of USD 500 million for international genebanks. It is only through mutual support and understanding between Crop Trust, CGIAR and other donors, that the necessary funding can be obtained for CGIAR genebanks while maintaining the integrity of the Endowment Fund mechanism. In 2020, the Crop Trust withdrew 4% from the Endowment Fund and raised a further USD 1.5 million in bilateral funds from the European Commission and the Government of Finland. In addition, the German Federal Minis-

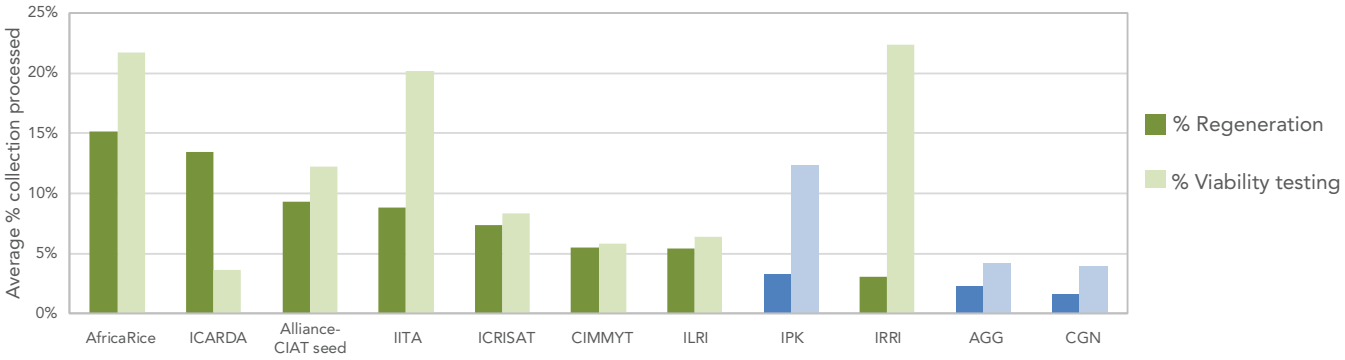


Figure 8. Rate of operation (annual average % collection regenerated/multiplied and viability tested) of CGIAR genebanks (green) compared to benchmark genebanks (blue). AGG=Australian Grains Genebank; CGN=Centre for Genetic Resources, the Netherlands - WUR; IPK=Leibniz Institute of Plant Genetics and Crop Plant Research

Table 15. Building efficiencies in the Genebank Platform

Level of entry	Methods	Expected outputs
Individual genebanks	• Quality management systems • Annual improvement reports • External technical reviews (5-year) • Costing reviews (10-year) • Testing of new technologies • Protocol optimization	• Documented standard operating procedures (SOPs) and system for auditing, review and improvement • Improvements triggered by recommendations from expert reviews • Compiled costs per activity/accession • Annual assessments of efficiency aims and progress • Piloting of imaging, automated seed sorting, automated germination testing, cryopreservation protocols
Thematic areas	Communities of practice and specialization: • Data management • Clonal crops • Seed quality management • Quality management systems • Germplasm health units • Impact fellows • Genetic resources policy	Workplans, strategies, research projects, revised procedures or SOPs, etc.
Platform level	• Shared performance targets/FAO standards/QMS • GOAL workshops • Platform level recommendations from technical and costing reviews • Benchmark studies • 2020 System Level Review of Genebank Costs and Operations	• Progress to "steady-state" operations • Aligned SOPs, templates and, in some cases, procedures (e.g. for same crops) • Adoption of good practices across Centers • System level actions to address recommendations • Shared policy and technical framework for strategic curation of collections (including archiving) • Consolidation & rationalization of roles, activities and collections

try for Economic Cooperation and Development (BMZ) provided USD 4.3 million through Window 2 to support the activities of the genebanks to reach performance targets. Together with the funding from BMZ, the Crop Trust met its commitment of USD 13 million to the Genebank Platform in 2020. In 2021, the commitment from the Crop Trust rises to USD 15 million.

Contextual risks: The importance of safety duplication has been made acutely evident in recent years through the use of deposits at the Svalbard Global Seed Vault to reconstitute the collections at ICARDA after its move from Syria and now with the use of safety duplicates in multiple tissue culture collections to replace cultures that are unable to be subcultured quickly enough in lockdown conditions. Safety duplication has substantially improved the resilience of CGIAR genebanks. However, tissue culture collections depend on a conveyor belt system of safety duplication with samples being multiplied continuously to ensure the whole collection remains duplicated at any one time. That system is at serious risk of collapse if the lockdown is extended and staff capacity is reduced. The only answer, at present, is cryopreservation, which enables a one-time duplication process. Once accessions are cryopreserved and safety duplicated, they will remain viable for decades without the need for replenishing unless the sample is used. The Clonal Crop Community of Practice has developed a Global Cryopreservation Initiative to take the existing work on cryopreservation to a new level and provide support to national genebanks to cryopreserve their collections too. The Crop Trust is assisting the group to raise funds with support from BMZ.

Institutional risks: The latest phase of technical reviews highlighted the weakness of data management systems in all Centers. Many collections are up to five decades old and some individual accessions are even older. The legacy of documentation has a major influence on what is known today about each individual accession's identity, health and viability. Poor documentation and data management inevitably will lead to a collection experiencing increasing redundancy both in its holdings and in the processes required to maintain them. As an example, current efforts to seek efficiency in viability monitoring and regeneration practices are challenged by the paucity of high-quality historical data on viability test results. These results would have helped to indicate how long seed lots can remain viable in storage without loss of viability and potentially led to reduced operations. The introduction of QMS and performance targets has improved documentation and critical review of processes in recent years. Now with the introduction of one data management system and all efforts being devoted to improving a single system rather than 11, it will be possible to build stronger data management practices and tools to ensure better long-term bookkeeping and managerial oversight of collections.

3. Financial Summary

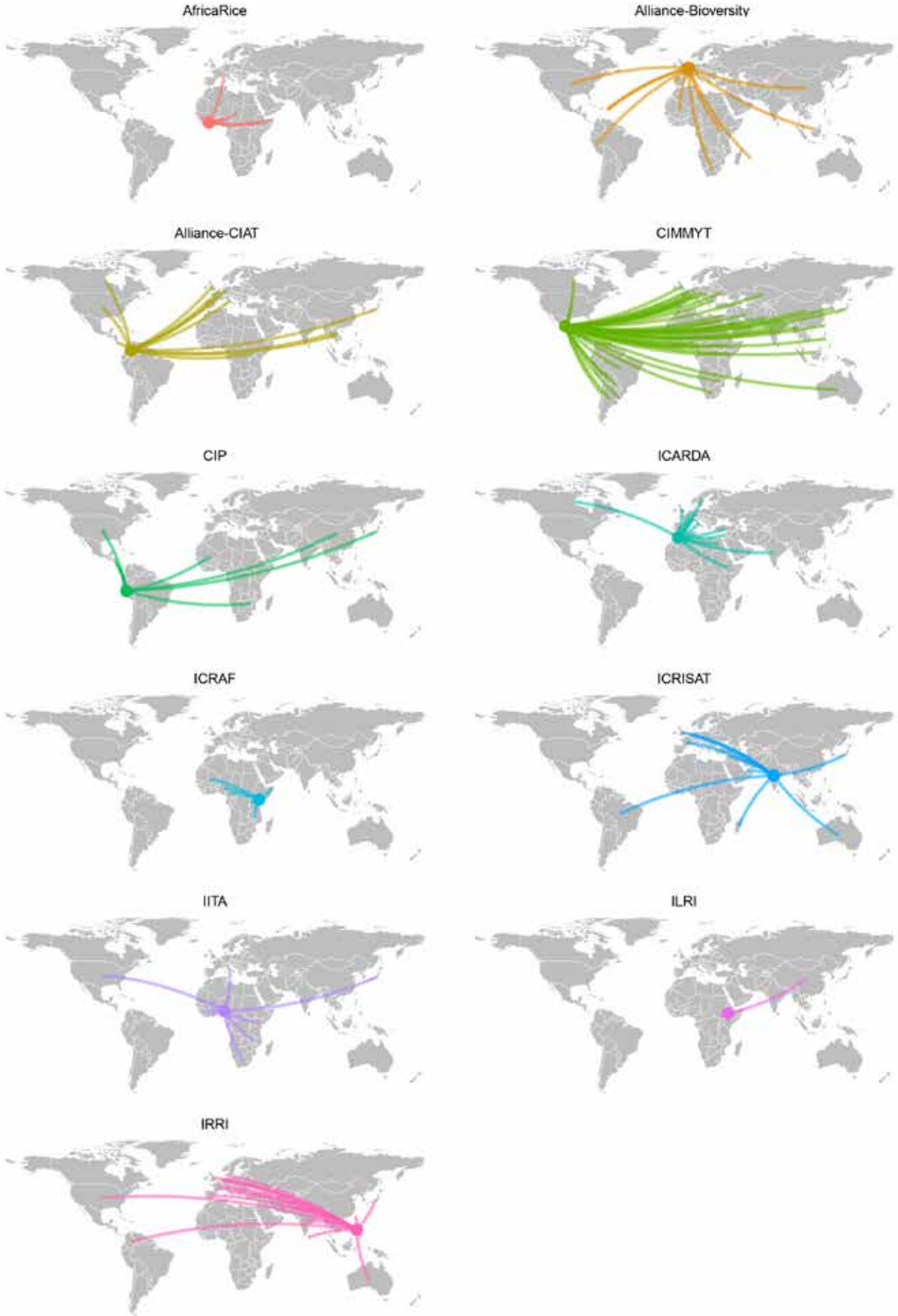
The ceiling of the Genebank Platform budget is fixed and closely follows the original proposal budget, which was based on costed routine operations and actions. In 2020, approximately one third of the Genebank Platform costs was covered by the Crop Trust. This contribution includes funds raised by the Crop Trust from the European Commission and Finland and is primarily used to support essential routine operations in nine of the 11 genebanks through long-term grants and a long-term partnership agreement. BMZ supported W2 in 2020 with the aim of funding upgrading actions to bring genebanks up to performance targets so that they become eligible for the Crop Trust long-term partnership agreements (LPAs). W1 and W2 funding from the UK Government was used to cover costs of routine essential operations that were not covered by the Crop Trust, as well as the Policy Module and GHUs.

Table 16. Financial Summary

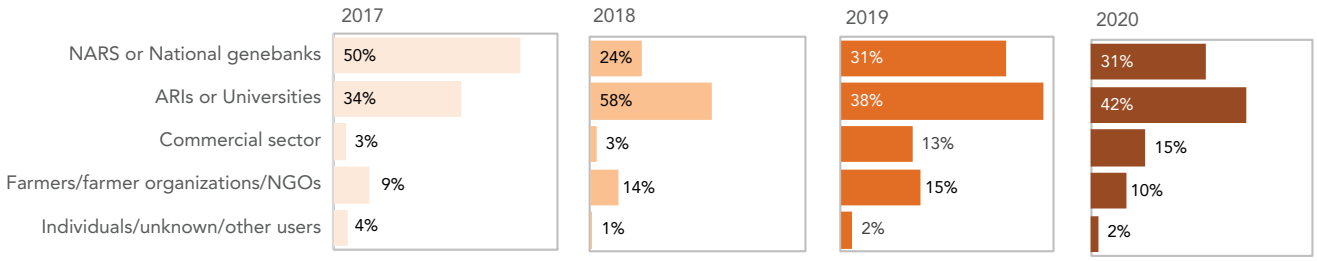
	Planned budget 2020			**Actual expenditure 2020**			**Difference**		
	W1/2	W3/ bilateral	Total	W1/2	W3/ bilateral	Total	W1/2	W3/ bilateral	Total
Module 1	14.18	11.31	25.49	13.05	10.31	23.36	1.13	1.00	2.13
Module 2	0.30	1.30	1.60	0.27	1.00	1.27	0.02	0.30	0.33
Module 3	0.70	0.00	0.70	0.67	0.00	0.67	0.03	0.00	0.03
Management & Support Costs	0.69	0.00	0.69	0.69	0.00	0.69	0.00	0.00	0.00
Platform Total	**15.86**	**12.61**	**28.47**	**14.69**	**11.30**	**25.99**	**1.18**	**1.31**	**2.49**

Note: Values in USD millions. Some numbers do not add up due to rounding.

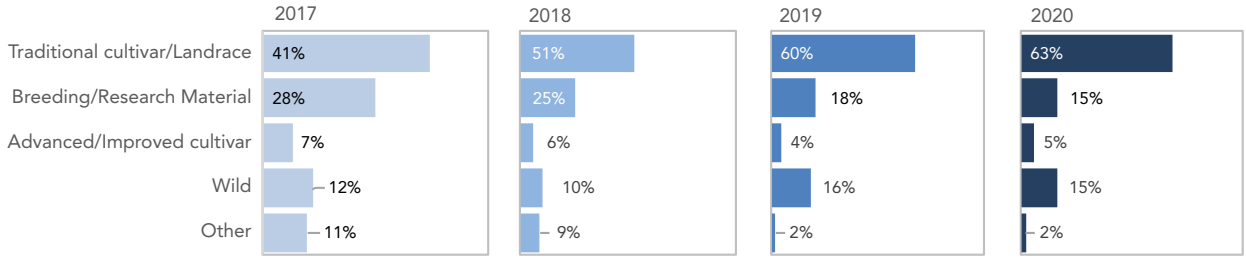
Annex



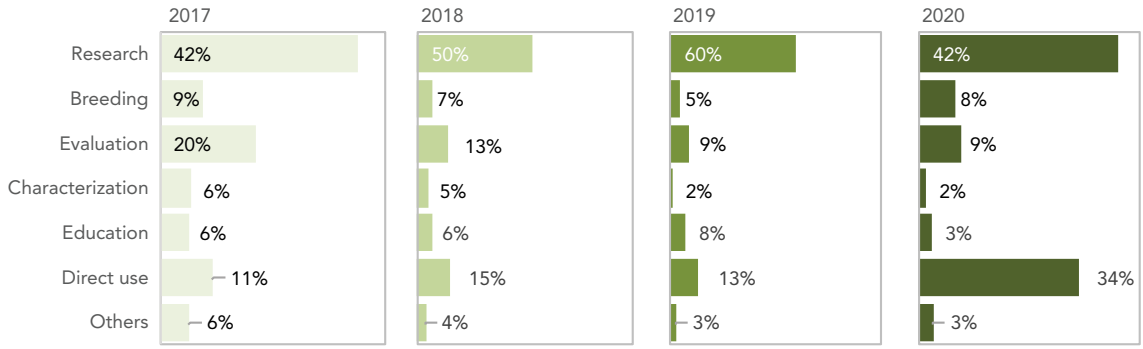
Annex Figure 1. Germplasm distribution by CGIAR Center in 2020



Annex Figure 2. Recipients of germplasm distributed by CGIAR genebanks, 2017 to 2020



Annex Figure 3. Types of materials requested, 2017 to 2020



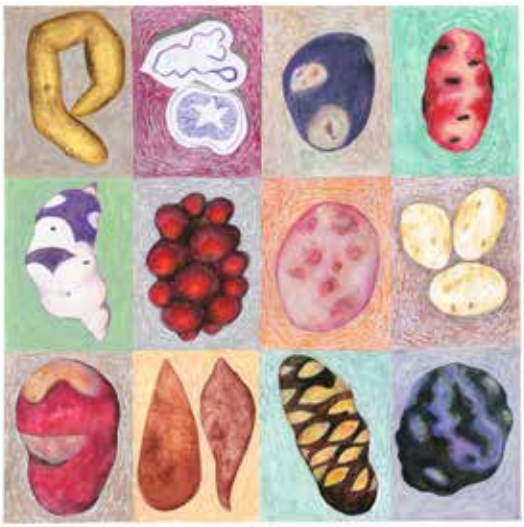
Annex Figure 4. Purpose of requests, 2017 to 2020

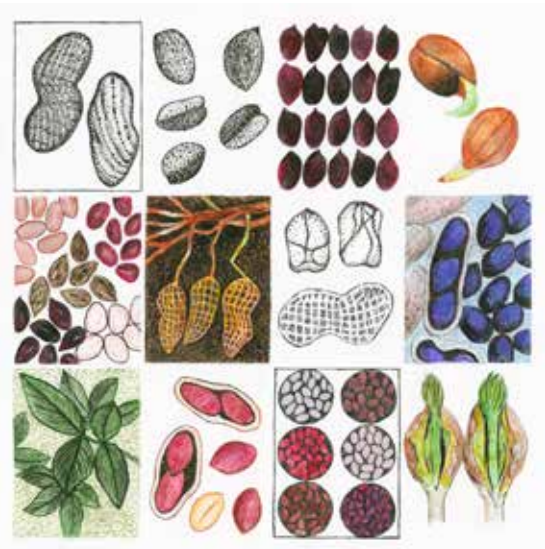
Annex Table 1. Participants in capacity development activities in 2020

Number of trainees	Female	Male
In short-term programs facilitated by the Platform	440	684
In long-term programs facilitated by Platform	1	1
PhDs	1	1

Annex Table 2. Update on actions taken in response to the IEA evaluation of the CGIAR research support program for Managing and Sustaining Crop Collections: Genebanks CRP

Status of response to this recommendation	Concrete actions taken for this recommendation	By whom	When	Comments	Link to evidence
Revisit the Parity Study to establish realistic and transparent budget for each Center genebank					
Ongoing	Costing reviews	Platform management	Visits per Center planned in 2018-2020	2017: IRRI 2018: Alliance-CIAT, CIMMYT, CIP, ICARDA 2019: ICRISAT, ILRI, ICRAF, Alliance-Bioversity 2020: AfricaRice, IITA	https://bit.ly/2QSUOlv
Promote the Genebank Platform communications					
Ongoing	Genebank Platform website actively maintained and promoted. Facebook and Flickr pages were launched in mid-2018	Science communications specialist	Annual	2020: The website received 18,070 users during 2020 who accounted for 39,299 page views. The Facebook page has more than 1,120 followers and monthly reaches nearly 10,500 people. The Flickr page offers 814 images. The Vimeo pages has 31 videos. 1 email newsletter was sent out in 2020 to 713 subscribers.	www.genebanks.org www.facebook.com/GenebanksCGIAR/ www.flickr.com/photos/genebankplatform/
External validation of QMS					
Ongoing	Technical reviews	External reviewers	Visits per Center planned in 2019-2020	2019: Alliance-CIAT, CIMMYT, CIP, ICARDA, IITA, IRRI 2020: AfricaRice, Alliance-Bioversity, ICRAF, ICRISAT, ILRI	www.genebanks.org/resources/genebank-reviews/
Enhance linkages between genebank characterization and breeders' evaluation and pedigree data					
Ongoing	Minting of DOIs Enriching data on collections through focal subsets	Use module	Annual	99% of accessions with DOIs Genesys has 135 subsets published and 433 characterization and evaluation datasets uploaded from CGIAR genebanks.	www.genesys-pgr.org/





CGIAR Genebank Platform

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